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CONTENTS

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ADDRESS OF THE PRESIDENT OF THE UNITED STATES[1]

The national government has a special and a profound interest in the gathering of the country's scientific leaders which you are beginning to-day in the capital city. No other single agency has so extensively relied upon the men and women of science as has the government. The personnel of the government service and the figures of the annual appropriation alike testify to this. The government has been foremost in employing, and most liberal in endowing science.

Let me say at once, however, that I do not intend to imply that we have been impressively liberal in dealing with the individual scientists who conduct these activities of the government. The most casual inspection of the salary lists of scientific workers in Washington will make very plain that it is toward science, not the scientists, that the country has been officially generous.

I was impressed with a new realization of the extent and importance of the scientific activities which center here in Washington by some figures showing the geographical distribution of members of your association. In proportion to its population there are more than five times as many of your members here as there are in any state.

I wish time would permit a brief suggestion of the amazing variety, the wide ramifications and the enormous value to the whole people of these scientific activities which are conducted under the administrative departments. Whether in studying the stars or in mapping the bottom of the sea; whether in making two blades of grass grow where one formerly grew; whether in developing a chemical compound that will destroy life or one that will save it; whether in weighing an atom or analyzing the composition of the most distant star—whatever the problem of human concern or social advancement, the scientific establishment of the government has enlisted the men and the means to consider it and ultimately to solve it.

So, as one particularly interested in this governmental university of practical and applied science, I welcome your great gathering to Washington. You represent the interests, the forces and the endless

[1] Given at the White House to members of the American Association for the Advancement of Science and affiliated societies meeting in Washington.

activities which literally from day to day are conquering new domains and adding them to the imperial realm of human knowledge. The future of civilization is well nigh in your hands. You are the wonder workers of all the ages. The marvels of discovery and progress have become commonplaces, simply because their number has paralyzed the capacity of the mind for wonderment. Those of us who represent social organization and political institutions look upon you with a feeling that includes much of awe and something of fear, as we ask ourselves to what revolution you will next require us to adapt our scheme of human relations.

But we know that you are animated by a profound purpose to better the estate of men. We are confident that society will somehow devise institutions capable of adaptation to the changed circumstances with which you are surrounding the business of living in our world. We trust ourselves to you perhaps with some doubt as to what you may finally do with us and to us, but at least with firm convictions that your activities will save life from becoming very monotonous. And, besides, we realize that if we did not give you our confidence you would go ahead without it.

It is a wonderful thing to live in a time when the search for truth is the foremost interest of the race. It has taken endless ages to create in men the courage that will accept the truth simply because it is the truth. Ours is a generation of pioneers in this new faith. Not many of us are endowed with the kind of mental equipment that can employ the scientific method in seeking for the truth. But we have advanced so far that we do not fear the results of that process. We ask no recantations from honesty and candor. We know that we need truth; and we turn to you men of science and of faith, eager to give you all encouragement in your quest for it.

CALVIN COOLIDGE

SOME ASPECTS OF INTERNATIONAL COOPERATION[1]

IT would be superfluous to address to you words of welcome. Washington is yours; you have made it what it is. You represent the aristocracy of effort without which democracy would be arid and fruitless. We who greet you come out of the struggle to hold what has been won; to protect the gains of the past from reckless squandering; to provide educational facilities so that the heirs of all the ages may be able to enjoy a reasonable portion of their inheritance; to make it possible for men to live together without seeking to destroy each other; in short, the never-ending task of getting the best out of things as we already know them. But you hold the promise of additions to the resources of humanity, the staking out of new possessions in the unseen world; of fresh discoveries and a richer life. If civilization is to advance it will be your doing, and the best we can hope of governments is that they will not stand too much in your way.

We are deeply interested in the promotion of peace. But there are only two methods by which we really may assure peace. The one is the long and difficult process of drying up the sources of controversy, of getting rid in some amicable fashion of actual causes of difference. The other is by developing new and enlarged conceptions of national interests and thus avoiding the strife due to narrow and artificial concepts, by mutual appreciation of the advantages which will accrue by pursuing paths of peace and by an adjustment of our international relations more in harmony with the methods and revelations of science. When difficulties are emphasized, we have a demonstration at hand. What may be done in conceiving national interest in terms of peace is happily illustrated in our relations with Canada, an object lesson not only to other peoples but to our own people in dealing with others. There are no two peoples anywhere, whatever historic antagonism may exist between them, however lavishly the seeds of distrust have been sown in valiant hearts ever ready to defend their country's honor, but would find on even a brief, if dispassionate, examination guided by the dictates of reason, that they had much more to gain by a well-directed cooperation than by pursuing the illusion of the gains of force. I am in hearty sympathy with those who would make aggressive war a defined crime, but such definitions, like other legal concepts, in order to be effective, must be sustained adequately by sentiment and we make the most rapid progress as we convince the practical judgment that unnecessary resort to force is a stupid blunder. It is your work that points to the benefits of peaceful cooperation that are within our grasp. Science, it is true, forges the weapons of war and constantly develops new and more terrible instruments of destruction. But she is far more eloquent as she points to the wastes of strife, the retarding of progress, and the vast opportunities which are open to industrious peoples if they are able to abandon their mutual fears and destroy the artificial barriers to community of enterprise. We wish no lowering of the standards of patriotism, no lessening of

[1] Address of Charles E. Hughes, Secretary of State, at the opening meeting of the American Association for the Advancement of Science at the Memorial Continental Hall, Washington, on the evening of Monday, December 29, 1924.

patriotic ardor, no weakening of the fiber of men and women ready at any cost to defend their country against attack upon its liberties, but rather a more enlightened patriotism, a more intelligent appreciation of what love of country demands, a desire to make friends and to find means to stifle distrust and to encourage confidence. To assure peace, this disposition must be found in other countries as well as in our own, but we should leave no doubt in word or deed of our own sentiment.

We should think in terms of the cooperation of peoples and not simply of governments. Science knows no political boundaries; she recruits her conquering chieftains from all climes and races. It may be an Austrian monk, revealing the secrets of plant inheritance; or a New Hampshire farmer's boy who learns to fashion instruments of the utmost delicacy and precision; or a Serbian herdsman taking youthful lessons in communication by listening through the ground; or a Japanese devotee of medical research isolating and cultivating microorganisms. In this field all are coworkers and pride is not of race or of tradition, but of achievement in the interest of humanity.

You have properly and insistently urged that international cooperation in scientific research is not only desirable, but absolutely necessary. There are most important enterprises which, if undertaken at all, must be conducted by international collaboration. Take, for example, the world-wide study of earthquakes and of various astronomical phenomena. In history, archeology, zoology, botany, geology and in any other of what are called the natural history or historical sciences little progress can be made in the study of what is fundamental unless there is opportunity to examine all the parts and aspects of the earth. Thus it is manifest, as has well been said, that considered as a local science geology gave only fragments of the earth's history, these partial records being separated in such a way as to suggest intervening periods of cataclysm or destruction. This was the natural interpretation of early investigators, but to-day with a knowledge of a large part of the earth's surface these gaps have been filled and a continuous history is available. It is not possible to have a complete history of life if you have an interrupted geological record, and yet this history is the world's most important story and the foundation of philosophy. You can not have an adequate history of peoples, or even of governments, if you rely exclusively upon data which are obtained in any one nation. And when we come to the enlargement of our knowledge of the universe, whatever may be the value of the discoveries and interpretations made in any one observatory, it is obvious that there can be little progress unless there are stations widely scattered over the earth and the bits of knowledge thus acquired are pieced together.

In truth, scientific achievement is not individualistic, but is the work of groups either consciously formed or produced by the essential correlation of effort. This essential cooperation has recently been described to me in this picturesque manner: "It grows like a building. One man may lay the capstone and get the credit, say an American scientist, but the stone may be laid upon a brick put into place by a Japanese and another by a German, and all may be held in place by the generalization of a Frenchman or a Scandinavian. A scientific problem is like a crossword puzzle worked out in a family circle. The solution may be held up until someone, perhaps accidentally, supplies the keyword that interlocks the rest." It may be added that in science we have a puzzle that is never solved; rather, a succession of puzzles, each answer raising new questions for which there must be a fresh collaboration.

It must be recognized that effective international cooperation depends quite as much on national organization and on appropriate interchanges as upon the creation of distinctive international bodies. There are national obligations which must be met and which can be made adequately only by the aid of governments.

The place of scientific research in our governmental economy should have more appropriate recognition. We develop bureaus, but with all our indebtedness to investigation we are still lacking in proper appreciation of scientific work. It is not comforting to our pride to think of the eminent scientists who are serving our government without adequate recompense or the losses in personnel we sustain by lack of appropriate provision for those who would be our greatest benefactors. If the test of civilization is in the sense of values there is little room as yet for boasting. The most competent organization of national scientific work which will seek, hold and suitably reward investigators of the highest rank is the fundamental requirement.

Then there is the responsibility which each nation should assume of properly assembling, arranging and safeguarding all data and records within the limits of its territory. Each nation should consider itself a trustee in the interest of humanity of all the results of researches in matters either touching itself directly or related to general questions dealing with wider regions. This safeguarding of data and records should be supplemented by coordination of effort and an assembling of results which will make it possible readily to command whatever may be found in any department as to any subject. The tendency

is strong among departments to treat themselves as little separate governments, but, whatever distribution of endeavor may be necessary for convenience or economy, government in its relation to its guardianship of scientific data should recognize its undivided responsibility.

Each nation should also acknowledge its obligation in the interest of necessary international cooperation to make readily available to other nations its assembled data and records. The mutual understanding and support of all peoples relating to any subject of research will give ultimately to each investigation and to each separate locality the largest possible measure of result. This sense of mutual interest and obligation will be of especial importance in opening opportunities throughout the world for archeological inquiries. We deprecate all suggestions of the monopolizing of such researches or their results to the prejudice of reasonable requests to prosecute investigations on fair terms. We trust that our scholars and the representatives of our museums and scientific institutions will receive a cordial welcome wherever they go throughout the world, in the realization that they are not serving selfish interests but seeking to advance the knowledge of mankind.

It is fitting that we should recognize what has already been achieved in the line of competent organization. This effort was stimulated by the great war, the conduct of which was largely based on a knowledge of science and its applications. I am informed that at the beginning of the war the Germans showed an ability "to mobilize science in a national emergency" beyond that of other nations at that time, and that since then, and in part because of that fact, the leading nations have taken definite steps towards the encouragement and support of scientific investigations. England has set up a special government Department of Scientific and Industrial Research. In the United States a National Research Council has been organized by the National Academy of Sciences. Japan and Australia have recently set up national research councils. Canada, I am told, has a similar undertaking, and in two or three European countries new scientific enterprises of similar character have been developed. Then there is the federating effort of the International Research Council which has established a number of affiliated international unions covering special fields of science, as the International Astronomical Union, an International Union of Pure and Applied Chemistry; an International Mathematical Union, an International Union of Pure and Applied Physics; an International Union of Scientific Radiotelegraphy. These organizations naturally lead to arrangements for special international scientific conferences. Thus we are at the threshold of a new era of international cooperation in the scientific field. This can not fail to add strength to the influences which make for better understandings between peoples and for a desire to adjust their differences so that they may enjoy the fruits of peace.

We should make acknowledgment to you for the benefit of the by-products of your labors. If to an increasing degree we have the security of sound public opinion, if the extravagances and diatribes of political appeals fail of their object, and if, notwithstanding the apparent confusion and welter of our life, we are able to find a steadiness of purpose and a quiet dominating intelligence, it is largely because of the multitude of our people who have been trained to a considerable extent in scientific method, who look for facts, who have cultivated the habit of inquiry and in a thousand callings face the tests of definite investigations. With scientific applications on every hand, the American people are daily winning their escape from the danger of being fooled. There are, it is true, many false prophets who are active in those areas of exertion where patient inquiry and regard for facts are not prized, but their following, while strident, is apparently not increasing.

We need your method in government; we need it in law-making and in law-administering. We need your interest in knowledge for its own sake; the self-sacrificing ardor of your leaders; your ceaseless search for truth; your distrust of phrases and catchwords; your rejection of every plausible counterfeit; your willingness to discard every disproved theory however honored by tradition, while you jealously conserve every gain of the past against madcap assault; your quiet temper, and, above all, your faith in humanity and your zeal to promote the social welfare. We need your horizon; your outlook on the world. We need the international cooperation which makes more effective the essential national endeavor and brings us nearer together as members of one human family, who in the presence of science can not remain estranged, but must find means of reconciling their several interests in the harmony of their common aspirations and for the common good.

Charles E. Hughes

THE MEANING OF SCIENTIFIC RESEARCH[1]

I have been assigned the task of speaking upon the meaning of scientific research. Some of you will say,

[1] Lecture delivered before the Sigma Xi Club of New York University, Tuesday, November 25, 1924.

"Why talk about that? Every one knows what scientific research is; there are no two opinions about it." I have had many discussions with my colleagues at Columbia University and in other places about this question: "Is such and such experimental work a scientific research or is it not?" The answer to it is not very obvious. That which characterizes true scientific research is the mental attitude. Two persons may be doing the same thing as far as we can see—and yet one is doing scientific research and the other is not, because one of them has a certain mental attitude and the other has not. That attitude may be the result of training, or it may be the result of innate genius.

Take, for instance, Joseph Henry, one of our best-known American scientific research men. He had only a high-school education at the Albany high school. When he graduated, he went into practical work, doing some surveying in the state of New York, which meant principally pulling chains, reading angles, etc.; nothing very scientific about it. Then he accepted a position as instructor at the Albany high school and immediately began doing experimental work all by himself, with no guidance from outside. But watch him in his work! How does he start? He starts with the problem of making a better electromagnet than any ever made—not an ordinary one. If one wishes to make a real advance in any line he must know what other people have done in that line. Henry learned everything that other people had done in constructing a fine electromagnet, and he succeeded in making a better one than anybody had ever made up to that time.

When a man builds an electromagnet, he is going of course to make and break an electrical circuit. Henry observed that he got a much longer spark when he broke the circuit—the same battery being in the circuit—than when he made the circuit. There came to his mind immediately something which had never suggested itself to anybody else's mind; namely, self-induction. He knew at once that he had made a great discovery. Then, instead of being satisfied with that discovery, he went on rapidly to study its meaning. He said to himself, "There must be, for the same reason, mutual induction," and he experimented with that until finally he proved most of the phenomena of mutual induction which we know to-day. By these experiments, his discovery of self-induction and his verification of mutual induction, of secondary sparks, etc., he also made an invention—the electromagnetic telegraph. He was the real inventor of the electromagnetic telegraph, although people do not know it, because he never made any fuss over it. He didn't care about the electromagnetic telegraph. He cared more about his scientific studies than about their application to definite, practical purposes. The invention of the telegraph did not divert him from his purely scientific work.

This is the mental attitude of the real, scientific research man, one who displays a burning desire to see more and more of the eternal truth, and to see it as soon as possible rather than to stop on the way in order to find its practical applications.

John William Draper, who taught at New York University for many years, is another brilliant illustration of this peculiar mental attitude. He was a physician, I believe, by training, and not an abstract scientist. Physicians at no time have been famous for a great knowledge of abstract science. It is not in their line. Although he was a physician, Draper was the first to study radiation, a subject which had nothing at all to do with medicine. In 1847 he published his first paper on temperature radiation, and showed how temperature changes the color of the light emitted by a hot body. In fact, he was the beginner of the theory of the black body, developed thirteen years later by Kirchhoff and by Bunsen in connection with their discovery, in 1860, of spectrum analysis.

In the same year, 1847, another physician, Herman Helmholtz, only twenty-five years of age, published a wonderful essay on the "Principle of conservation of energy," one of the most important scientific essays of the nineteenth century.

Five years before that, another physician, Robert Mayer, published his paper demonstrating that heat is a form of energy and that a certain quantity of heat corresponds to a certain definite quantity of mechanical work.

There you have two other young physicians engaged, like John Draper, in scientific research in the domain of abstract science, who could not be turned away by professional duties. Draper, for instance, did very fine photographic work. Photography in those days was a new art. Draper took it up because he saw in it something scientifically new. Do you suppose that he tried to increase his income by photographing faces? Not a bit of it. He spent his nights trying to photograph the moon and stars. That is science. The other is a commercial pursuit. He and Helmholtz and Mayer had the mental attitude of scientific research men. I will describe another remarkable case. Carnot discovered, just a hundred years ago, in 1824, one of the greatest principles in science, known to-day as Carnot's principle. He was twenty-eight years old when he did it. Now, what was his training? His father was one of the famous generals in Napoleon's army, and he saw to it that his son was educated to become an officer in Napoleon's army, so he sent him to the École Polytechnique in Paris, where he studied military science. But as soon as young Carnot could,

he dropped military science and took up scientific research. He had no elaborate training in scientific research, but he had the mental attitude of the scientific research man. He was born with it.

Before I proceed further I wish to answer a question which you are entitled to ask. The question is: "Do not these examples which you have given demonstrate that it is not necessary to train a man in scientific research? There have been many men who have made great discoveries, without such training," I say, "No, they do not prove anything of the kind." These were men of great genius, and great genius does not require training. In fact, that is a distinction of a genius, a man who can do work of the highest type without training. He is born with it. He brings it into the world. But for every genius in this world there are many millions who are not geniuses, who are just ordinary mortals, and ordinary mortals have to be trained.

When, therefore, we speak of the meaning of scientific research, we must connect it with the men who are not men of genius, who are just fine, ordinary mortals—above the average, yes, perhaps considerably above the average, but, nevertheless, below the level of genius. These are the men who do the work of the world. The genius starts it; he is the pioneer. The man who develops new ideas and applies them to the happiness of mankind is the ordinary, average, scientific research man, and we need as many of them as we can possibly get. We can not have too many.

What is it we have to teach young men or young women in order to create in them the mental attitude of scientific research? I prefer to let bigger men than myself talk about that. I will only say this. The scientific research man studies nature and its various operations. Nature speaks a universal language, in which the sentences are constructed in accordance with absolute logic. She has the universal and the most correct language of all. Our human language and logic are only poor copies of the language and logic of nature, and every man and every woman must learn the language and logic of nature in order to get the attitude of a scientific research mind.

I will quote some passages from men who discussed this subject over fifty years ago. President Barnard, who gave us the first wave theory of light in America, between 1850 and 1860, and later became president of Columbia College, said this, I think at a meeting of scientific men and teachers: "If we would fit men to cultivate nature [that is, to study nature] our earliest teachings must be things and not words." He was protesting against the old method of preparing boys and girls for college. They were taught grammar—English grammar, Latin grammar, Greek grammar and sometimes a foreign-language grammar—before they were taught any science at all. Then when they entered college, they got more grammar in the various languages and did not take up science seriously until the junior year. This was too late, too late! I know this from my own experience. The earliest stimulus in science came to me before I had entered college, and the most inspirational scientific information I received when I was a little over ten years of age from my teacher in a public school—a few things, but I got hold of them and they stuck to me. They were always the foundation of my interest in science. I read about them, and kept on reading until I was about sixteen or seventeen. Then I had to take up Greek and Latin because they were required for entrance to college. I went to college, and I knew more science when I entered than when I left. That was the kind of teaching of science we had in those days, over forty years ago. It was so at Columbia College, at New York University, and at all other colleges. Hence that protest by Barnard which I quoted above. There was also a protest by Joseph Henry, who was then secretary of the Smithsonian Institution, by John William Draper, who was professor of chemistry here in New York University, and President Andrew White, of Cornell, and others. They saw that real science, the language and logic of nature, was not taught soon enough, and they started a movement in the direction of introducing a new system of scientific education and a new spirit of scientific teaching—a spirit which would produce the mental attitude of a scientific research mind.

They were not groping in the dark at all, but they thought that their cause would be better served if they had an apostle from the other side to advocate their cause before the people of the United States. In every country people are more apt to listen to a man of great reputation from three thousand miles away than to a man who is among them. So they invited Tyndall, who was a great physicist and a great lecturer. He came over here, so that he might "show the uses of experiment in the cultivation of natural knowledge, hoping that this would promote scientific education in this country," and he succeeded. He delivered a course of six lectures in ten or twelve cities like New York, Washington, Boston, New Haven, Philadelphia, etc., and he had enormous audiences who came to see his brilliant experiments (he was lecturing on light), and to hear the language and the logic of a distinguished devotee to science. Enthusiasm for scientific study was wonderfully aroused, and that is just what Joseph Henry, John William Draper, Barnard and Andrew White wanted. That was the beginning of the great movement in this country in the direction of a new method of scientific education for developing

the mental attitude which characterizes a scientific research man.

When leaving, Tyndall gave a farewell address, in which he said, among other things:

To no other country is the cultivation of science in its highest form of more importance that it is to you, the people of the United States. In no other country would it exert a more benign and elevating influence. The original investigator constitutes the fountain of knowledge. It belongs to the teacher to give this knowledge the requisite form, an honorable and often difficult task, but it is a task which receives its final sanction when the teacher himself honestly tries to add a rill to the great stream of scientific discovery. Indeed it may be doubted whether the real life of science can be fully felt and communicated by the man who has not himself been taught by direct communion with nature. For that power of science which corresponds to what the Puritan fathers would call "experimental religion," you must ascend to the original investigator.

You see the plan he recommended and which was recommended by his friends who invited him over here was not only to have great scientific investigators, but that every teacher who teaches science should be given a chance to do original investigation, because without that they lacked the power of teaching. It only comes, you know, from direct communion with nature, or, as I have called it, from a direct *study of the language and logic of nature.*

People did not quite understand Tyndall's first sentence, "In no other country is the cultivation of science in its highest form of more importance than to you; in no other country would it exert a more benign and elevating influence." Why would it in this country exert a more benign and elevating influence than, say, in Russia or in Turkey or in China? Why did we need it more than any other country? That I am going to explain by quoting now from John William Draper, who made the following comment upon Tyndall's remarks: "Nowhere in the world are to be found more imposing political problems than those to be settled here," and then comes another sentence, "nowhere a greater need of scientific training." Behold, what this man said, that in a country of political problems, we need for their solution scientific training? What does this mean?

Draper did not say any more than that, but Andrew White said this, more than fifty years ago: "I will confine myself to the value in our political progress of the spirit and example of some of the scientific workers of our day and generation." (And he had undoubtedly Joseph Henry and John William Draper in mind). "What is the example of that spirit? It is an example of *zeal,* zeal in the search for truth, of *thoroughness,* of the truth sought in its wholeness, of *devotion* to duty, without which no scientific work can be accomplished, of *faith* that truth and goodness are inseparable." That was the value in our political progress of the spirit and example of some of the scientific workers of that day. That is the thing of real value which we in our political progress should imitate in the lives of these scientific men.

Then, in 1886, came Henry Rowland, of Johns Hopkins, the great American physicist. He made an address in Baltimore on the value of a scientific research laboratory, in which he eulogized the mind in which that mental attitude is found which I call the mental attitude of scientific research. He said this, "This is the mind which is destined to govern the world!" He was a bold man. Some of you may have known him. I knew him very well. He believed in what he said, and he said what he believed, and this was his bold prophecy: "This is the kind of mind [this is the kind of mental attitude] we need in the solution of all our human problems, not only the problems of science." In this he simply repeated what the others, Draper, White and Barnard, had said fourteen years before.

When Rowland said this, the status of scientific research was somewhat better than it was fourteen years before, because the movement started then had succeeded. He had organized a laboratory at Johns Hopkins University, the object of which was training in scientific research work. Then came the laboratories of Harvard, Yale and other institutions, and scientific research work began to be taught in American universities, imitating somewhat the methods of German universities. We had to imitate somebody, because we had to start somewhere before we developed a system of our own. Now, we have developed a system of our own, and I want to say a few words about that.

The scientific research movement, or, as Andrew White called it, "the movement for higher endeavor," became stronger and stronger in our universities. From the universities it was transplanted into American industries, and it is extremely strong there now. The scientific research activity in our industries is marvelous, when you compare the work done to-day with the work done no longer than twenty-five years ago. We need to-day many more research workers, not only for the proper teaching of science, which Tyndall recommended, but we need them also for another purpose. Scientific research work in the industries has increased so enormously that the industries need many men, university-trained men, to do their work. The supply of scientifically trained research men for the industrial research laboratories is smaller than the demand. The industries themselves are clamoring for better men with a better type of training, so that in this respect

the universities are beginning to be led by the industries, instead of vice versa. But that will not last long. The universities will lead again, I am sure of it.

The industries are anxious that the universities should do their work of training research men as well as it possibly can be done. I heard one captain of industry remark one day that, perhaps, it would be a good thing if the industries would set aside a part of their profits, derived from the development of scientific research, for the benefit of universities, to enable them to give better and better instruction in scientific research. I also know that some of the industries are subsidizing some of the university laboratories for carrying on certain research work; not developmental work, but purely scientific research work. The best of the industries are not trying to debase the real research work of universities by giving them problems which are nothing but technical development work. The industries can do that themselves. What they would like to see the universities do is to carry on pure scientific research work, and to produce young men who have a truly scientific mental attitude. This cooperation between the scientific work in the universities and in the industries has already produced wonderful results, and it will produce more and more, and I am quite sure that some day the achievements from this cooperation will prove even to the most ordinary type of mentality that the best work can be done only by experts who have the proper training. That is the doctrine which we need in this country, and if it is adopted, not only in the industries, but in every activity of government, then the prophecy of Rowland will be fulfilled. I am sure that it will be adopted some day, because that is one of the best ways to make democracy safe for the world.

M. I. Pupin

Columbia University

THE FOUNDATION OF THE THEORY OF ALGEBRAIC NUMBERS[1]

II

We shall next see that certain modifications are to be introduced in order that the usual theorems of arithmetic hold true in the more general realms. For example, in the very simple realm that exists by adjoining $\sqrt{m}$ to the usual realm, it may be proved when m is greater than 3 and is not a perfect square that the Euclid Algorithm is not applicable, and there is no such thing as the greatest common divisor in the usual sense. By way of illustration observe that in the realm $R(\sqrt{-5})$ we have $21 = 3.7 = (4+\sqrt{-5})(4-\sqrt{-5}) = (1+2\sqrt{-5}) \times (1-2\sqrt{-5})$, where all the factors are irreducible integers. Thus it is evident that the factorization of an integer into its irreducible (or prime) factors is in these extended realms *not* a unique process as is the case in the usual realm of arithmetic and as is also true in the realms $R(i)$ and $R(\omega)$. And here is the difficulty that mathematicians at first found perplexing, a difficulty which it was necessary to overcome before the laws of arithmetic could be regarded as universal.

The problem may be recast as follows: Let ρ be the root of an algebraic equation of the nth degree whose coefficients belong to the usual (natural) realm of rationality and let ρ be adjoined to the usual realm. We thereby create an algebraic realm $R(\rho)$ of the nth degree. *Determine the arithmetic of this extended algebraic realm.*

By making use of the above example we shall anticipate the results that follow, particularly those that are connected with the *Theory of Ideals.* The reader is thus enabled to see the trend of the later theory and with this in view he is asked to accept without proof the statements given immediately below.

Write $T_1 = (3,\ 1+2\vartheta)$, $T_2 = (3,\ 1-2\vartheta)$, $T_3 = 1,\ 1+2\vartheta)$, $T_4 = (7,\ 1+2\vartheta)$ where $\vartheta = \sqrt{-5}$. It may be proved by taking the products of the ideals that

$$T_1\ T_2 = (3),\ T_1\ T_3 = (1+2\vartheta),\ T_1\ T_4 = (4-\vartheta),$$
$$T_2\ T_3 = (4+\vartheta),\ T_2\ T_4 = (1-2\vartheta),\ T_3\ T_4 = (7).$$

None of these quantities is a unit in $R(\vartheta)$ and they are all prime ideals since, if N denotes the *norm* of an algebraic quantity and that is the product of the quantity and its conjugates, so that $N(T_1) = (3, 1+2\vartheta)\ (3, 1-2\vartheta)$, then is

$$N(T_1) = N(T_2) = 3;\quad N(T_3) = N(T_4) = 7.$$

Thus it is seen that the factorization of 21 into its prime ideal factors, namely, $21 = T_1\ T_2\ T_3\ T_4$ is a unique process. It is also seen that the different methods of factorization given above for the integer 21 in the realm $R(\vartheta)$ are had through the different combinations in pairs of the T's.

It thus appears that the prime ideals in this extended realm take the place of prime integers in the usual arithmetic; and one of the objects before us is to establish what is the historical origin of these prime ideals, as well as to study what they are.

Returning to the discussion of the proof that the Greater Fermat Theorem does not admit integral solutions, consider the simple case

[1] Concluding part of the address of the vice-president and chairman of Section A—Mathematics, American Association for the Advancement of Science, Washington, December 31, 1924.

(1) $$z^4 = x^4 - y^4 = (x - y)\ (x + y)\ (x - iy)\ (x + iy) = T_1\ T_2\ T_3\ T_4,$$

and observe that the factors on the right-hand side are irreducible in R(i). Since the complex quantities in this realm obey the same laws as do the real quantities in their realm, we may derive a *correct* proof that equation (1) *can not* be solved in real integers.

Consider next the equation

$$z^n = x^n - y^n = (x - y)\ (x - \alpha y)\ (x - \alpha^2 y) \ldots (x - \alpha^{n-1} y) = T_1 \cdot T_2 \ldots T_n,$$

where α is a primitive root of $x^n = 1$. The T's being quantities of the realm $R(\alpha)$, are of the form

$$T = a_0 + a_1\alpha + a_2\alpha^2 + \ldots a_{n-1}\alpha^{n-1},$$

where the a's are rational integers.

There are now two questions before us. 1°: Are the factors T irreducible in $R(\alpha)$? It is found that they are. 2°: Is this factorization unique? It is found that it is *not*. According to the testimony of Guldenfinger and of Grassman, Kummer (1810–1893) proved the Fermat Theorem as to the requirements of the first condition and submitted his MS about (1843) to Dirichlet. Dirichlet pointed out that the second condition must also be satisfied.

In 1844 in his celebrated paper, "De numeris complexis, etc.," Kummer wrote,

Maxime dolendum videtur, quod haec numerorum realium virtus, ut in factores primos dissolvi possint, qui pro eodem numero semper iidem sint, non eadem est numerorum complexorum, quae si esset, tota haec doctrina, quae magnis adhuc difficultatibus laborat, facile absolvi et ad finem perduci posset.

However, in a letter to Liouville (April, 1847) (see *Journal de Mathématiques,* Vol. 12, p. 136) Kummer again wrote,

Quant à la proposition élémentaire, qu'un nombre composé ne peut être decomposé en facteurs premiers que d'une seule manière, je puis vous assurer qu'elle n'a pas lieu généralement tant qu'il s'agit de nombres complexes de la forme T [defined above] mais qu'on peut sauver en introduisant un nouveau genre de nombres que j'ai appelé nombre complexe idéal.

Thus it was Kummer who, in this maze of doubt and uncertainty, found a means of overcoming the difficulties and dilemmas that had been encountered. By the introduction of the prime ideal factors it was seen that the rational prime integers are no longer the extreme elements in the extended realms of rationality. Although Kummer's principles had to do for the most part with the algebraic numbers which are derived from the roots of unity, the ideal numbers which he introduced served as a guide for the general theories that were soon afterwards invented.

Among others who also were working in the theory of algebraic numbers that are formed from the roots of unity may be mentioned Jacobi, Cauchy and Eisenstein.

L. E. Dickson in his "History of the Theory of the Theory of Numbers," Vol. II, p. xix, writes:

Although Gauss had proved in 1832 that the laws of elementary arithmetic hold also for complex numbers (numbers like $5 + i7$) and made a brilliant application of them in his investigation of biquadratic residues, the theory of algebraic numbers was really born in 1847. For it was then that the mathematical world became definitely conscious of the fact that complex integers (as T above) do not obey in general the laws of elementary arithmetic. This historical fact came to light through discussions of lacunae in the attempted proof of Lamé that if n is an odd prime, $x^n + y^n = z^n$ is not satisfied by such complex integers. Other errors of the same nature were made by Wentzel and by so great a mathematician as Cauchy. Curiously, Kummer himself made the error, in a letter of about 1843 to Dirichlet, of assuming that factorization is unique, so that his initial proof of Fermat's Theorem was incomplete. But Kummer did not stop with the mere recognition of the fact that algebraic numbers do not obey the laws of arithmetic; he succeeded in restoring the laws by the introduction of ideal elements, this restoration of law in the midst of chaos being one of the chief scientific triumphs of the past century.

We are pleased to add that Dickson himself has made some far-reaching discoveries in this same field which must give him in the mathematical world the recognition accorded to Kummer, Dirichlet, Dedekind and Minkowski.

The theory of analytic functions was developed in the French school. Dirichlet became well versed in this subject during his stay in Paris and upon his return to Germany through his lectures, particularly on the partial differential equations, established in the German school a theory that was already well known in France, due to the efforts especially of Poisson, Fourier, Ampère and Monge. Applying his knowledge of analytic methods to the problems that arise in the consideration of complex units, Dirichlet was able on the one hand to establish a *fundamental* system of units for any algebraic realm and on the other hand he was able to derive a formula for the presentation of the number of classes into which the algebraic numbers of a realm may be distributed. These two principles must be included in any arithmetic of algebraic numbers as we have already indicated. And thus, as Kummer has said, Dirichlet made an epoch in this theory as Descartes had done in the application of analysis to geometry.

Riemann learned the analytic method from Dirich-

let and this led him far into his geometrical researches regarding which we have already spoken. Thus it is seen that the work of the French school is basal in many of the results that have been indicated in this paper.

We are now brought face to face with two other disciples of Dirichlet, namely, Kronecker and Dedekind. Both of these men felt the necessity of generalizing the notion of the ideal factors for the case of any algebraic quantities, and that is, of any quantity of an algebraic realm however generalized. Observe that the ideal numbers of Kummer had to do with cyclotomic (circular) realms, which are had through the adjunction of the roots of a binomial algebraic equation to the usual realm of rational numbers. These ideal numbers in the form presented by Kummer are susceptible of simplification and generalization.

Frobenius in his "Gedächtnissrede auf Leopold Kronecker" writes:

The genius of Gauss in the treatment of the cyclotomic numbers (roots of unity) make algebra pay tribute to arithmetic and Jacobi's conquering strength lays at her (arithmetic's) feet the measureless treasures of formulas from the theory of elliptic functions and into her service forced the finest methods of analysis. It is Kronecker's everlasting service that he made this self-sufficient science become a servant to both algebra and the Theory of Functions.

And Kronecker in his "Antrittsrede" to the Berlin Academy said: "Die Verknüpfung dieser drei Zweige der Mathematik erhöht den Reiz und die Fruchtbarkeit der Untersuchung."

The investigations of the complex numbers formed from the roots of the Abelian equations led Kronecker to the algebraic-arithmetic problem of forming all Abelian equations for any realm of rationality. The solution of this problem he communicated to the Berlin Academy in 1853.

From this time on Kronecker laid especial emphasis upon the treatment of algebraic questions from an arithmetical point of view and in the investigation of such problems he entertained the idea of extending Gauss's conception of congruences with respect to a rational integer as modulus to the conception of congruences with respect to an arbitrary system of moduli, a conception which in its incipiency had already been conceived by Serret and by Schönemann. In the preface to Vol. I of Kronecker's Works, Hensel writes:

Under the name of *General Arithmetic* Kronecker understood the application of the conceptions and methods of the Theory of Numbers to the investigation of rational functions of any number of variables. This greatly extended field of investigation embraces the consideration of systems of integral numbers, the entire field of the theory of numbers, the investigation of linear systems, the theory of determinants, bilinear and quadratic forms and finally the general field of algebraic numbers and functions of one and of several variables.

Kronecker employed the systematic application of indeterminate coefficients in the definition of the ideal quantities and by using several variables in the formation of his functions he attempted to overcome many of the difficulties and to avoid many of the imperfections that are experienced in the use of one variable. Instead of the association of higher kinds of algebraic irrationalities he widened the dimension of the original realm of quantities by the introduction of forms of several indeterminates and thus he gave essentially new points of view for the realms of rationality which through such adjunctions contain not only numbers and functions of one variable but also functions of several variables; and through a finite number of integral algebraic quantities he was able to express all such quantities of the realm. Kronecker wished to see in the greatest common divisor of several integral quantities *not* the only thing common to such quantities. This he held is a common divisor of the first kind (Stufe). There are with him common divisors of a higher kind. The general method for the treatment of such quantities Kronecker presented in a condensed and exceedingly difficult form in a memoir entitled "Grundzüge einer arithmetischen Theorie der algebraischen Grösse," which he dedicated to his friend and teacher Kummer on the commemoration of the latter's seventieth birthday. The work may best be described in Kronecker's own words regarding Legendre's "Théorie des Nombres:" "It can not be regarded as a well-ordered and well-arranged work."

From what has been seen Kronecker wished to treat in its generality every branch of mathematics under the one heading "General Arithmetic," a theory which divested of its analytic properties should rest upon something akin to the rational integers as its final substructure. A systematic treatment of Kronecker's ideas with the natural extensions, ramifications and applications and not in the form of a *general arithmetic* or a *general analysis* is a work well worth doing by some capable young American.

As a rule great discoveries do not fall out of clear skies. It is usually with much patient wooing attended by prolonged labor and arduous toil that they are produced. Newton had his precursors and the

theory of fluxions was not the sudden output of a fertile brain. Fortuitously, the mathematicians mentioned above with possibly others served in guiding aright the one whose mathematical-philosophic genius gave an easy and comprehensive method for the treatment of algebraic numbers in all their generality. Richard Dedekind (1831–1916) devised, systematized and extended this theory from time to time and modestly incorporated his results as the "Eleventh Supplement of Dirichlet's Zahlentheorie." This excellent work was edited through several editions by Dedekind.

I produce here briefly the outlines of Dedekind's discoveries which, resting upon the deeply imbedded bases already considered, are to be regarded as the firm foundations of the theory of algebraic numbers.

Let a and b be any two fractional or integral numbers in the usual realm of rational numbers. Observe that the linear form $ax + by$, for integral values x and y, represent all those rational numbers that are divisible by the greatest common divisor of a and b. We may therefore say that any number t is divisible by the complex of numbers a and b (which complex denote by $[a, b]$), if it is possible to determine two rational integers x and y such that $t = ax + by$. This is an extension of the ordinary conception of divisibility in that t is divisible by a if $t = ax$, where x is an integer. This extension is clearly superfluous, so long as we remain in the usual realm of rational numbers; for in this case every number that is divisible by the complex $[a, b]$ is divisible by the greatest common divisor d of a and b, and reciprocally, every number that is divisible by d is divisible by $[a, b]$. Accordingly, we may write $d = [a, b]$.

It is quite otherwise if we extend the realm of rational numbers to an algebraic realm Ω. The following definition is accordingly introduced: *The integral or fractional number λ is said to be divisible by the complex $[\alpha, \beta]$, if there exist two integers ξ and η such that $\lambda = \alpha\xi + \beta\eta$ where all quantities belong to Ω.*

This conception is no longer superfluous. For, if δ is a quantity through which both α and β are divisible, then every number that is divisible by $[\alpha, \beta]$ is clearly divisible by δ. However, every number that is divisible by δ is *not* divisible by $[\alpha, \beta]$. For, if this were true, then δ would itself be divisible by $[\alpha, \beta]$ and would accordingly be expressible in the form $\delta = \alpha\xi_1 + \beta\eta_1$, where ξ_1 and η_1 are integers in Ω. Hence δ would be the greatest common divisor of α and β in the sense that is usual in the theory of rational numbers. If, however, Ω is an arbitrary algebraic realm of rationality, we meet with a difficulty. For, if in the definition of *divisibility* we limit the discussion to a definite realm and if we define divisibility as we have just done for the rational numbers, there is no greatest common divisor in general for two numbers of Ω as indicated above; if, however, we neglect the realm of rationality Ω and permit the discussion to extend to the general realm of all algebraic numbers, there is something which corresponds to the greatest common divisor in the theory of natural numbers. There is then, however, no such thing as a prime number and the theorem regarding the unique factorization of a number into its prime factors does not exist. However, we can not lose sight of the theorem regarding the unique distribution of a number into its prime factors and therefore the conception of the theorem regarding the unique distribution of a number into its prime factors and on this account the conception of the divisibility through the complex $[\alpha_1 \beta]$ is no longer superfluous; it becomes necessary.

The above definition is applicable to the complex $m = [\alpha_1, \alpha_2, \alpha_3, \ldots]$, which consists of more than two algebraic numbers in Ω. Accordingly, an algebraic number λ is said to be divisible by this complex if $\lambda = a_1\xi_1 + a_2\xi_2 + \ldots$, where the ξ's are integers in Ω.

The investigation may be restricted in that the ξ's are required to be rational integers. The collectivity of all algebraic numbers that are expressible through the linear form $\alpha_1 x_1 + \alpha_2 x_2 + \ldots, x_1, x_2, \ldots$ being rational integers was called by Dedekind a *modul.* It may be observed, if functions of one or more variables with coefficients that belong to a fixed realm are written in the place of the α's, that the modular systems of Kronecker are nothing other than the moduls of Dedekind.

A number λ is said to be divisible by a modul or modular system if λ is a number of the modul, that is, if λ is contained in the modul, and that is, if rational integral numbers $x_1, x_2, \ldots$ may be found such that $\lambda = \alpha_1 x_1 + \alpha_2 x_2 + \ldots$. Here we have encountered something which at first may appear as a "confusion of language" in that the conception of "divisibility" and of being "contained in" which heretofore have been opposed are now identical.

Dedekind offers also the following definition of a modul in order to give the theory a more philosophic setting in that it is independent of the notion of linear forms: *A modul is a system of numbers such that the difference of any two numbers of the system is a number of the system.* If $a_1, a_2, \ldots a_n$ are a finite number of quantities of Ω and if there is no linear relation among them with rational coefficients, these quantities constitute a *basis* of a *finite* modul. In this case $[\alpha_1, \alpha_2, \ldots \alpha_n]$ is called a modul of the nth order. We are then led through easy steps to the conception of equality of moduls, the greatest

common divisor, the least common multiple, the product and the quotient of moduls.

All numbers of the modul $\mathbf{m}$ are said to be divisible by $\mathbf{m}$, and if α is any such number, then is $\alpha \equiv 0 \pmod{\mathbf{m}}$; and α is said to be congruent to β (mod $\mathbf{m}$) and written $\alpha \equiv \beta \pmod{\mathbf{m}}$, if $\alpha - \beta$ is divisible by $\mathbf{m}$ and that is, $\alpha - \beta$ is a number of $\mathbf{m}$.

If $\mathbf{a}$ and $\mathbf{b}$ are two moduls and if $\mathbf{b}$ is divisible by $\mathbf{a}$, then the numbers of $\mathbf{a}$ fall with respect to $\mathbf{b}$ into a certain number of classes, which number is denoted by $(\mathbf{a}, \mathbf{b})$. Any number of a class may be selected as a representative of the class. We thus have as many representatives as there are classes.

These representatives have the following characteristics:

(1) They are all divisible by $\mathbf{a}$;

(2) The difference of no two of them is divisible by $\mathbf{b}$;

(3) Every number that is divisible by $\mathbf{a}$ is congruent to one of these numbers (mod $\mathbf{b}$) and to only one.

It is evident that if $\mathbf{a}$ is divisible by $\mathbf{b}$ that $(\mathbf{a}, \mathbf{b}) = 1$.

In general without assuming that $\mathbf{b}$ is divisible by $\mathbf{a}$, make the assumption that n elements $\beta_1, \beta_2, \ldots \beta_n$ of $\mathbf{b}$ are such that

$\beta_r = e_{r1}\,\alpha_1 + e_{r2}\,\alpha_2 + \ldots + e_{rn}\,\alpha_n \quad (r = 1, 2, \ldots n)$,

where the e's are rational numbers. Denote the determinant of these expressions by C. It may be proved that

$$\frac{(\mathbf{a}, \mathbf{b})}{(\mathbf{b}, \mathbf{a})} = \left| \, C \, \right|.$$

If in this expression $\mathbf{b}$ is divisible by $\mathbf{a}$, then the e's are integers and $(\mathbf{a}, \mathbf{b}) = |\,C\,|$.

By definition (1) a finite modul $\mathbf{a}$ is said to be *algebraic,* if all the numbers that are divisible by $\mathbf{a}$ are algebraic. (2) An algebraic modul $\mathbf{a}$ is an *integral algebraic* modul if all the quantities that are divisible by $\mathbf{a}$ are algebraic integers. (3) An integral algebraic modul is a *unit modul,* if 1 is divisible by this modul. These three definitions are restricted to finite moduls. To show that a finite modul is algebraic, it is only necessary to show that the modul has a basis which consists of only algebraic integers.

Theorem.—If $\mathbf{a}$ *is a finite modul which belongs to an algebraic realm* Ω, *there exists a finite modul* $\mathbf{b}$ *of* Ω *such that* $\mathbf{ab}$ *is a unit modul which consists only of algebraic integers.*

Theorem.—All the algebraic integers of a realm of the nth degree constitute a finite modul of the nth order.

There exists always in such a realm a modul $\mathbf{v}$ whose discriminant has a minimum value. This modul $\mathbf{v}$ is such that $\mathbf{v}^2 = \mathbf{v}$ and $\frac{\mathbf{v}}{\mathbf{v}} = \mathbf{v}$, so that $\mathbf{v}$ plays the same rôle in the algebraic realm as 1 does in the usual realm of rational numbers.

Theorem.—If $\mathbf{a}$ *is an arbitrary modul of the nth order in a realm* Ω *of the nth degree, then every number* β *of* Ω *may through multiplication by a rational integer be transformed into a number that is divisible by* $\mathbf{a}$.

An *ideal* is a modul of the nth order in a realm of the nth degree formed of the complex of values of a linear form $\alpha\xi + \beta\eta + \gamma\zeta + \ldots$, in which $\alpha, \beta, \gamma, \ldots$ are integral or fractional algebraic numbers of a fixed realm Ω and where $\xi, \eta, \zeta, \ldots$ are any integers of Ω. If $\mathbf{a}$ is an ideal and $\mathbf{v}$ the modul defined above, then is $\mathbf{va} = \mathbf{a}$. This is characteristic of an ideal and serves to define it, being in fact the best definition of an ideal. It may be proved that the greatest common divisor, the least common multiple, the product and the quotient of two or more ideals are ideals.

If α is an arbitrary number of Ω, then is $\mathbf{v}\alpha$ an ideal, a *principal* ideal. *Theorem.—If* $\mathbf{a}$ *and* $\mathbf{b}$ *are two ideals of* Ω, *there is one and only one ideal* $\mathbf{k}$ *such that* $\mathbf{ak} = \mathbf{b}$.

It may be proved that

$$\frac{(\mathbf{v}, \mathbf{v}\eta)}{(\mathbf{v}\eta, \mathbf{v})} = N(\eta) = N(\mathbf{v}\eta),$$

where η is an arbitrary number of Ω and N denotes its norm. This property of the principal ideal $\mathbf{v}\eta$ leads to the following definition. If $\mathbf{a}$ is an arbitrary ideal, then is

$$N(\mathbf{a}) = \frac{(\mathbf{v}, \mathbf{a})}{(\mathbf{a}, \mathbf{v})}$$

from which it follows that $N(\mathbf{v}) = 1$.

An ideal is said to be integral if it consists only of algebraic integers and this is true if $\alpha, \beta, \gamma, \cdots$ above are integers. We may observe further that in every such ideal there exist n integers $\gamma_1, \gamma_2, \ldots \gamma_n$ which have the property that every integer ι of the ideal may be expressed in the form $\iota = g_1\,\gamma_1 + g_2\,\gamma_2 + g_3\gamma_3 + \ldots$; where the g's are rational integers.

If $\mathbf{g}$ is an integral ideal, observe that

$$N(\mathbf{g}) = \frac{(\mathbf{v}, \mathbf{g})}{(\mathbf{g}, \mathbf{v})} = (\mathbf{v}, \mathbf{g}).$$

And this, as seen above, is the number of classes into which the integers of Ω may be distributed with respect to the integral ideal $\mathbf{g}$. This number plays fundamental rôles in the further development of the theory, for example, in the proof of Fermat's Lesser Theorem for ideals, in the determination of the number of classes into which an integral ideal may be distributed, etc.

Theorem I.—If two integral ideals $\mathbf{a}$ *and* $\mathbf{b}$ *are relatively prime, and that is, have no ideal factor in*

common save **v**, *and if* **c** *is a third ideal, then if* **bc** *is divisible by* **a**, *the ideal* **c** *is divisible by* **a**.

Theorem II.—If **a** *and* **b** *are two integral ideals that are relatively prime and if* **a** *and* **c** *are two integral ideals that are relatively prime, then the greatest common divisor of* **a** *and* **c**, *this common divisor of* **a** *and* **c**, *this common divisor being* **v**.

Theorem III.—An integral ideal **a** *is divisible by only a finite number of other ideals.*

If an integral ideal **a** has the property that it is divisible by itself and by no other ideal save **v**, it is called a *prime* ideal.

Theorem IV.—If a product of several integral ideals is divisible by a prime ideal, one of the ideals is divisible by this prime ideal.

Theorem V.—The Fundamental Theorem. Every integral ideal that is not **v** or a prime ideal may be *factored into a product of prime ideals and this factorization is unique.*

Observe that every algebraic integer when multiplied by **v** is a principal ideal and that the above theorems are applicable to it.

The integral ideals constitute one branch of the general theory of moduls. This general theory in its incipience comprises the Kronecker modular systems and indeed many other branches of mathematics that emanate from the general realms of rationality and include the Minkowski geometry of numbers, the treatment of the moduli of periodicity of the Abelian Integrals, etc.

As a rule the text-books on the usual theory of numbers make the positive integer the starting point and the theorems regarding such integers form the foundation of the theory; it appears also that the text-books on the theory of algebraic numbers are going to start with the integral ideal. It should be emphasized that such ideals have their general setting in the general modul theory just as *number* is the more general concept of the usual positive integer.

The theory as outlined above may be made dependent upon the fundamental theorems of Dedekind as given by him in the "Begrundung der Idealtheorie. Göttingen-Nachrichten 1895."

I. *If the ideal* **c** *is divisible by the ideal* **a**, *there exists an ideal* **b** *such that* **c** = **ab**.

II. *Every ideal may be changed through multiplication by a properly chosen ideal into a principal ideal.*

III. *Every finite modul that is different from zero may through multiplication by a properly chosen modul be changed into a modul which contains the number 1 and further consists of only integers.*

IV. *If* $\alpha_1, \alpha_2, \cdots, \alpha_n$ *denote any n numbers that are not all zero of a realm* Ω *of the nth degree, it is possible to derive by rational operations n other numbers* $\beta_1, \beta_2, \cdots \beta_n$ *of* Ω *which satisfy the two conditions, first that* $\alpha_1\beta_1 + \ldots + \alpha_n\beta_n = 1$, *and secondly, that the* n^2 *products* α_r, β_s *are all integers.*

If any three of the above theorems are proved, the fourth follows as a consequence.

Observe that throughout the entire discussion of this article a fixed stock-realm R has been the realm of reference. This stock-realm was the usual realm of rational numbers. The theorems derived have been for the numbers of another realm, say Ω_1, which was deduced by adding (adjoining) to R an algebraic quantity. This algebraic quantity was in turn the root of an algebraic equation whose coefficients were rational numbers (and that is, numbers of R). It is possible to introduce a third realm Ω_2 which bears towards Ω_1, the same relation as Ω_1 had with respect to R, and so on indefinitely. Instead of the ideals that are introduced for Ω_1 other (more general) ideals exist for Ω_2 through the introduction of more general norms, discriminants, etc. It may be proved that the same rules, laws and principles exist in the more general realms as were true in Ω_1. And thus it becomes manifest that the principles of arithmetic are true universally and that is, in any algebraic realm whatever taken with respect to any arbitrary algebraic stock realm as realm of reference.

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SCIENTIFIC EVENTS

THE NANSEN POLAR EXPEDITION

THE Christiania correspondent of the London *Times* writes: The news that Dr. Nansen, after nearly 30 years spent in labor far away from the Arctic, will again return to the work of his youth is sure to attract general attention. Dr. Nansen has taken his decision. He will not only join the North Pole Expedition of the German Commander Bruns, but he will become its leader. By his famous expedition with the *Fram* in the years 1893–96, Dr. Nansen gained a reputation which, coming after his crossing of Greenland, placed him in the highest rank of Arctic explorers, and his interest in the North Polar basin has not waned.

Just as Dr. Nansen in 1893–96 had no ambition of reaching the North Pole apart from scientific exploration, so he is without this ambition on this occasion also. At the meeting of the Geographical Society he declared the flight over the Pole to be a matter of secondary importance, and in a subsequent interview he expressed the hope that Captain Amundsen will reach that goal next summer. Dr. Nansen will certainly not try to overtake Amundsen.

The projected Nansen Expedition is primarily in-

terested in obtaining scientific results. In a seaplane flying 90 to 100 miles an hour, and with a very limited accommodation, it is impossible to take topographically trustworthy photographs of regions over which the seaplane is passing, nor is it possible to sound the depths of the Arctic Ocean. But in an airship such as Commander Bruns contemplates, with a capacity of 150,000 cubic meters, supplied with four engines and with a crew of 50 men, conditions will be different. The airship will be flown at 80 miles an hour, and each engine is to be supplied with fuel for 100 hours. The whole distance, Murmansk—Alaska—Murmansk, is about 4,000 miles. The whole journey is expected to last four weeks.

Dr. Nansen is in no hurry to leave. He knows that no great things can be achieved without great preparations, and as his scientific ambition is not overshadowed by other considerations, he can afford to wait until everything is in order. At any rate, he says, we are not going to start until 1927.

HALL OF FAME FOR ENGINEERS

Plans for an Inventors and Engineers Hall of Fame have been announced for the proposed $5,000,000 National Museum of Engineering and Industry to be erected on The Mall in Washington. Decision to establish such a hall in the central rotunda of the museum was reached unanimously by the Board of Direction of the Museum Foundation which has undertaken to raise a national endowment of $10,000,000, and among those who probably will be represented in marble or in bronze will be Charles P. Steinmetz, Alexander Graham Bell, Thomas A. Edison, Orville and Wilbur Wright, Eli Whitney, Captain John Erikson, Mergenthaler and Robert Fulton.

Thomas A. Edison, Orville Wright, Charles F. Brush, Leo H. Baekeland, Edward G. Acheson, Frank J. Sprague and Edward Weston have been elected vice-presidents of the museum movement organization.

Charles M. Schwab, president of the Bethlehem Steel Company, and Melville E. Stone, former head of The Associated Press, also have accepted posts on the Honorary Advisory Board, where they will serve with Secretary Herbert Hoover, Dr. Charles W. Eliot and General George W. Goethals.

Records of the achievements of the outstanding leaders in invention and engineering, now scattered throughout the country, are to be assembled, and all original models, so far as recoverable, are to be obtained for the museum.

Many American colleges specializing in technical education have already attempted on a limited scale to maintain museums exhibits, where members of the student body can study in graphic detail the evolution of the technical field in which they are preparing to take their places. The present movement for the National Museum of Engineering and Industry embraces, beside the central edifice in Washington, a chain of local museums of industry, situated in the various industrial sections and affiliated with the parent institution for the diffusion of technical knowledge to all parts of the country.

The Board of Direction also determined to dedicate a suitable chamber adjoining the Hall of Fame, to be designated "The Founders' Room." Herein will be honored, by suitable busts, tablets and other memorials, those public-spirited individuals, societies and corporations whose contributions in energy, time or money shall have made possible the establishment in Washington of the world's greatest industrial museum institution.

THE YALE ASTRONOMICAL STATION IN SOUTH AFRICA

Dr. Frank Schlesinger, accompanied by Mrs. Schlesinger, sailed from New York on December 27 for South Africa *via* England. He is taking with him the 26-inch photographic objective intended for the Yale southern telescope. After selecting the exact site, work will be begun at once on erecting the observatory and mounting the telescope, which he hopes to have in operation by May or June.

The mounting for the telescope was constructed for the most part in the Yale Observatory shop at New Haven, and was temporarily erected in New Haven. It has now been crated and will be shipped direct from New York to South Africa at the end of January. Mr. Walter O'Connell, foreman of the shop, is to accompany the mounting and to take part in its erection in South Africa.

Dr. H. L. Alden, now of the McCormick Observatory, has been appointed assistant professor of astronomy at Yale University and will be in charge of the Yale station in South Africa. He expects to sail from New York at the end of April and begin work with the telescope in June, when Dr. Schlesinger will return to this country.

Mr. C. H. Hall, Jr., formerly in charge of the Observatory of the Maryland Academy of Sciences, has been appointed assistant to Dr. Alden in the operation of the telescope. He will arrive at the station early in February.

This telescope is to be the principal instrument at what will be Yale Observatory's chief observing station. The work of the telescope will at first consist in the determination of the parallaxes of many stars to supplement similar work now being done in the northern hemisphere; the determination of the proper motions of many faint stars, and work in cooperation with other observatories in the selected areas. It is expected to send later other instruments to the station.

OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AT the Washington meeting of the American Association the following officers were elected:

PRESIDENT

M. I. Pupin, professor of electro-mechanics, Columbia University, New York, N. Y.

VICE-PRESIDENTS

Section A (Mathematics), W. A. Roever, professor of mathematics, Washington University, St. Louis, Mo.

Section B (Physics), H. M. Randall, professor of physics, University of Michigan, Ann Arbor, Mich.

Section C (Chemistry), H. B. Cady, professor of chemistry, University of Kansas, Lawrence, Kansas.

Section D (Astronomy), A. E. Douglass, professor of astronomy, University of Arizona, Tucson, Ariz.

Section E (Geology and Geography), R. A. Daly, professor of geology, Harvard University, Cambridge, Mass.

Section F (Zoological Sciences), H. S. Jennings, professor of zoology, Johns Hopkins University, Baltimore, Maryland.

Section G (Botanical Sciences), R. B. Wylie, professor of botany, State University of Iowa, Iowa City, Iowa.

Section H (Anthropology), Chas. B. Davenport, director of the Station for Experimental Evolution, Carnegie Institution of Washington, Cold Spring Harbor, N. Y.

Section I (Psychology), C. E. Seashore, professor of psychology, State University of Iowa, Iowa City, Iowa.

Section K (Social and Economic Sciences), F. R. Fairchild, professor of political economy, Yale University, New Haven, Conn.

Section L (Historical and Philological Sciences), W. A. Oldfather, professor of classics, University of Illinois, Urbana, Ill.

Section M (Engineering), F. G. Cottrell, director of the Fixed Nitrogen Laboratory, U. S. Department of Agriculture, Washington, D. C.

Section N (Medical Sciences), A. J. Carlsen, professor of physiology, University of Chicago, Chicago, Ill.

Section O (Agriculture), C. V. Pper, agrostologist, U. S. Department of Agriculture, Washington, D. C.

Section Q (Education), Otis W. Caldwell, director of the Lincoln School, Teachers College, Columbia University, New York, N. Y.

PERMANENT SECRETARY

Burton E. Livingston, director of the laboratory of plant physiology, Johns Hopkins University, Baltimore, Maryland.

GENERAL SECRETARY

W. J. Humphreys, professor of meteorology, George Washington University, and U. S. Weather Bureau, Washington, D. C.

TREASURER

J. L. Wirt, Carnegie Institution of Washington, Washington, D. C.

SECRETARIES OF THE SECTIONS

Section A (Mathematics), R. C. Archibald, associate professor of mathematics, Brown University, Providence, R. I.

Section B (Physics), A. L. Hughes, Washington University, St. Louis, Mo.

Section C (Chemistry), Gerald Dietrichson, University of Illinois, Urbana, Ill.

Section D (Astronomy), Philip Fox, professor of astronomy, Northwestern University, Evanston, Ill.

Section E (Geology and Geography), G. R. Mansfield, U. S. Geological Survey, Washington, D. C.

Section F (Zoological Sciences), G. T. Hargitt, professor of zoology, Syracuse University, Syracuse, N. Y.

Section G (Botanical Sciences), S. F. Trelease, professor of plant physiology, University of Louisville, Louisville, Ky.

Section H (Anthropology), R. J. Terry, professor of anatomy, Washington University School of Medicine, St. Louis, Mo.

Section I (Psychology), F. N. Freeman, professor of psychology, University of Chicago, Chicago, Ill.

Section K (Social and Economic Sciences), F. L. Hoffman, Babson Institute, Babson Park, Mass.

Section L (Historical and Philological Sciences), F. E. Brasch, Congressional Library, Smithsonian Division, Washington, D. C.

Section M (Engineering), N. H. Heck, U. S. Coast and Geodetic Survey, Department of Commerce, Washington, D. C.

Section N (Medical Sciences), A. J. Goldfarb, professor of biology, College of the City of New York, New York, N. Y.

Section O (Agriculture), P. E. Brown, Iowa State College, Ames, Iowa.

Section Q (Education), A. S. Barr, University of Wisconsin, Madison, Wis.

ELECTED MEMBERS OF THE COUNCIL

L. O. Howard, Chief of the Bureau of Entomology, U. S. Department of Agriculture, Washington, D. C.

D. T. MacDougal, director of the Desert Laboratory, Carnegie Institution of Washington, Tucson, Ariz.

ELECTED MEMBERS OF THE EXECUTIVE COMMITTEE

B. M. Dugger (1925), Missouri Botanical Garden, St. Louis, Mo.

Edwin B. Wilson (1928), Harvard School of Public Health, Boston, Mass.

Vernon L. Kellogg (1928), permanent secretary of the National Research Council, Washington, D. C.

ELECTED MEMBERS OF THE FINANCE COMMITTEE

George K. Burgess, *Chairman*; chief of the U. S. Bureau of Standards, Washington, D. C.

Arthur L. Day, director of the Geophysical Laboratory of the Carnegie Institution of Washington, Washington, D. C.

ELECTED MEMBERS OF THE COMMITTEE ON GRANTS FOR RESEARCH

Joseph Erlanger, professor of physiology, Washington University School of Medicine, St. Louis, Mo.

Nevin M. M. Fenneman, professor of geology, University of Cincinnati, Cincinnati, Ohio.

SCIENTIFIC NOTES AND NEWS

Dr. M. I. Pupin, professor of electro-mechanics in Columbia University and distinguished for his contributions to mathematical physics, has been elected president of the American Association for the Advancement of Science.

The Washington meeting of the American Association and the forty-six national scientific societies affiliated with it was unparalleled in size and in the number of scientific papers presented. The full report of this meeting, prepared by the permanent secretary, will be given in a special number of Science to be issued later in the month.

Professor William B. Scott, of Princeton University, has been elected president of the Geological Society of America, at the Ithaca meeting of the society. Other officers were elected as follows: *First vice-president,* Reginald W. Brock, Vancouver, B. C.; *second vice-president,* Marius R. Campbell, Washington, D. C.; *vice-president* to represent the Paleontological Society, R. S. Lull, New Haven; *vice-president* to represent the Mineralogical Society, Arthur S. Eakle, Berkeley, Calif.; *secretary,* Charles H. Berkey, New York; *treasurer,* Edward B. Matthews, Baltimore, Md.; *editor,* Joseph Stanley Brown, New York.

Dr. T. C. Chamberlin, emeritus professor of geology at the University of Chicago, has had conferred upon him a gold medal by the Society of Economic Geologists, meeting at Cornell University, in recognition of his contributions to geology.

The Maxime Bôcher prize of the American Mathematical Society for the best literary contribution to mathematical science has been awarded to Professor E. T. Bell, of the University of Washington, and Professor S. Lefschetz, of the University of Kansas. The prize which was established last year will in the future be awarded every five years.

Sir Ernest Rutherford and Sir George James Frazer have been appointed members of the Order of Merit. Other scientific men on the King's New Year's honor list include the following who have received knighthoods: Professor John Adams, Professor R. H. Biffen, Professor Gowland Hopkins, Principal J. C. Irvine and Dr. John Campbell.

At a meeting held on December 16, the Academy of Natural Sciences of Philadelphia elected as correspondents the following: Edward A. Birge, Waldemar C. Brögger, Charles Whitman Cross, Robert A. Harper, Ross G. Harrison, Ernst J. O. Hartert, Karl Jordan, Auguste Lameere, Henri A. Menegaux, William Patten, J. O. Edmond Perrier, Anton Reichenow, Benjamin L. Robinson and Brör Y. Sjöstedt.

At the annual meeting of the American Engineering Standards Committee on December 11, Mr. Charles E. Skinner, a representative of the American Institute of Electrical Engineers, was elected chairman for the year 1925, and Mr. Charles Rufus Harte, representative of the American Electric Railway Association, was elected vice-chairman.

Rear Admiral C. F. Hughes, in charge of fleet training in the United States Naval Department, has been elected president of the American Society of Naval Engineers for 1925, in succession to Captain J. T. Tompkins, who has headed the society for the past two years.

Leslie Brown, of Lenox, Inc., Trenton, N. J., was elected president and chairman of the New Jersey Clay Workers Association and Eastern Section, American Ceramic Society, at the annual meeting, New Brunswick, N. J., held on December 19.

The board of governors of the Institute of Medicine, Chicago, announces the following elections for the coming year: Drs. James B. Herrick, *president;* Charles A. Elliott, *vice-president;* George H. Coleman, *secretary;* Dallas B. Phemister, *treasurer,* and Ludvig Hektoen, *chairman* of the board of governors.

Dr. Alexander Wetmore, biologist in the Biological Survey, has been appointed superintendent of the National Zoological Park, succeeding Ned Hollister, who died recently.

Professor Franklin Sumner Earle, of the Experiment Station, Cuba, has accepted an appointment as Sugar Cane Technologist on the staff of the Tropical Plant Research Foundation. His address will be Herradura, Cuba, where he will have charge of a field station for cane propagation and variety studies.

James L. Kilpatrick has been elected vice-president of the Western Electric Company in charge of the telephone department to succeed Dr. Frank B. Jewett, who has been made vice-president of the American Telephone and Telegraph Company.

Bradford Noyes, Jr., Ph.D. (Cornell, '24), has accepted a position as physicist in the technical department, research division, of the Taylor Instrument Companies, Rochester, New York.

H. T. Edwards, of the office of fiber plant investigations in the Bureau of Plant Industry, sailed from San Francisco on November 29 for Manila, where he will be engaged during the next six months, in cooperation with the Philippine Bureau of Agriculture, in encouraging the more general use of improved methods in producing, cleaning and packing abacá, maguey and sisal.

COLONEL JOSEPH UZAC, of the French War Ministry Medical Service, Colonel Robert Picqué, associate professor of anatomy in the Bordeaux Faculty of Medicine, and Captain Martin W. Flack, of the British Air Force Medical Service, delegates to the recent meeting of the Association of Military Surgeons of the United States, San Antonio, Texas, from November 13 to 15, were tendered a dinner at the Union League Club, New York, on November 28.

F. M. ROOT, associate in medical entomology at the Johns Hopkins University School of Hygiene and Public Health, sailed January 3 for Brazil to make a study of the mosquitoes of that country with reference to the malaria problem.

DR. PAUL KAMMERER, of the University of Vienna, is again visiting the United States.

H. T. STEARNS, of the U. S. Geological Survey, who recently finished work on the geology of the Kau district island of Hawaii that had been started by Messrs. Meinzer, Clark and Noble, left Honolulu on November 29 for a trip around the world primarily to view the volcano fields of Japan, Java and Italy.

DR. V. BJERKNES, professor of hydrodynamics at the Geophysical Institute, Bergen, Norway, and research associate at the Carnegie Institution of Washington, gave two illustrated lectures at the institution on the forces which lift airplanes, and problems in dynamical meteorology, on January 6 and 8. Dr. John A. Anderson, physicist at the Mount Wilson Observatory, gave an illustrated lecture on "An experimental method of studying high temperatures," at the institution on January 5.

AT the invitation of various local sections of the American Chemical Society and other interested groups, Professor Marston Taylor Bogert, of Columbia University, will deliver public lectures, upon the subject of "Science and art in the perfume industry," in the following cities: January 20, Cleveland; January 21, Akron; January 22, Ann Arbor; January 23, Chicago; January 24, Evanston; January 27, Madison; January 28, Minneapolis. These lectures will be illustrated by the Bush collection of colored lantern slides, by perfume products from various parts of the world and by finished perfumes.

AT the one hundred thirty-fifth convocation of the University of Chicago on December 23, Professor Julius Stieglitz, chairman of the department of chemistry, delivered the convocation address on "Chemistry in the service of man."

DR. A. R. DOCHEZ, professor of medicine at the College of Physicians and Surgeons, Columbia University, will deliver the sixth Harvey Society lecture at the New York Academy of Medicine, on the evening of January 17. His subject will be "Etiology of scarlet fever."

DRS. CHARLES H. MAYO and William A. Plummer, Rochester, Minn., will deliver the three Beaumont lectures, under the auspices of the Wayne County Medical Society, Detroit, on January 26 and 27, on "Problems of the thyroid."

WILLIAM SNOW MILLER, professor emeritus of anatomy at the University of Wisconsin, addressed The Radiological Society at its recent meeting in Kansas City, Mo., on "Key points in lung structure."

PROFESSOR W. A. TARR, of the University of Missouri, while residing at Cambridge during the Michaelmas term of 1924 for the purpose of studying the collections in the Sedgwick Museum of Geology, delivered at Dr. Rastall's request five lectures to the class of economic geology, dealing with the copper, lead and zinc deposits of the United States.

ALLAN WYON, sculptor, has presented to the University of Leeds a bronze medallion in memory of his brother, the late Dr. G. A. Wyon, formerly lecturer in pathology in the university.

ON the wall of the west entrance of Tower Court at Wellesley College has been placed a tablet in memory of Lady Margaret Huggins. The inscription on the tablet reads: "To Lady Huggins, an English astronomer of note, who, in recognition of the intellectual justice done to women at Wellesley College, bequeathed, with other valuable gifts in the observatory and library, the reproductions of the old masters in Tower Court." Lady Huggins was the wife of Sir William Huggins, distinguished for his work in spectroscopy.

OLAF HOFF, civil engineer, known for his contributions to methods of tunneling, has died at the age of sixty-five years.

DR. EUGENE SOLOMON TALBOT, well known for his work in stomatology and formerly professor of stomatology in Rush Medical College, died on December 20 at the age of seventy-seven years.

DR. CLADIUS B. KINYON, former professor of obstetrics and gynecology at the University of Michigan, died on December 22, aged seventy-three years.

DR. GEORGE DOWNING LIVEING, president of St. John's College, Cambridge, England, and for forty-seven years professor of chemistry in the University of Cambridge, died on December 26, aged ninety-seven years.

GEHEIMRATH HUGO v. SEELIGER, professor of astronomy and director of the observatory of the University of Munich, has died at the age of seventy-five years.

DR. JAMES ALFRED WHELDON, of Liverpool, England, died on November 28. A correspondent writes: "Apart from his professional work as pharmacist on the medical staff of H. M. Prison, at Walton, Mr. Wheldon was an eminent and widely known botanist, who, in 1923, was vice-president of Section K (Botany), at the Liverpool meeting of the British Association. He was especially interested in bryophytes, and an authority on the difficult groups of the Harpioid Hypna and the Sphagna."

THE second general assembly of the International Astronomical Union will be held at Cambridge, England, from July 14 to 22, 1925.

A JOINT meeting of the American Physical Society and the Optical Society of America will be held at Columbia University on Friday and Saturday, February 27 and 28. The preliminary arrangements of the program are as follows: Friday morning, Session in charge of the Optical Society. Papers from members of the Optical Society. Friday afternoon, joint session. Papers from members of the Optical Society and from members of the Physical Society. Friday evening, informal get-together," probably at the Columbia Faculty Club. Saturday morning, Physical Society program, except for two invited papers from the Optical Society. Saturday afternoon, regular Physical Society program. Titles should be submitted to the secretary, Dr. F. K. Richtmyer, Cornell University.

THE twelfth annual meeting of the Indian Science Congress will be held in Benares, from January 12 to 17. The Maharaja of Benares, Sir Prabhu Narain Singh Bahadur, has consented to be patron of the meeting, and Dr. M. O. Forster, director of the Indian Institute of Science, Bangalore, will be president. Professor S. P. Agharkar is general secretary and the local secretaries for the meeting are Professor L. D. Coueslant, department of engineering, Benares Hindu University, and Professor K. K. Mathur, of the department of geology.

ACCORDING to the *Journal* of the American Medical Association, ceremonies are to be held at Paris early in June, at the Académie de médecine, the Faculté de médecine and the Société de neurologie to honor the centennial of the birth of Charcot. Foreign governments and scientific societies have been invited to send delegates. The Société de neurologie will celebrate at the same time its sixth international reunion. The committee in charge is headed by Dr. Babinski, with P. Marie, Pitres and P. Richer as honorary presidents, and includes Jean Charcot and a number of Charcot's old pupils, with Dr. A. Souques, 17 rue de l'Université, Paris, secretary.

THE Sigma Xi Club of Carleton College, Northfield, Minn., is devoting this year's series of program meetings to a study of recent advances in the science of heredity. The year's program is: History of the study of the science of heredity, The chromosomal basis of heredity, Hybridization, Variation and mutation, Heredity of sex, Heredity of acquired characters, Principles of heredity as applied to plant breeding, Principles of heredity as applied to eugenics.

THE Stanford University Medical School announces the following public lectures on medical subjects to be given at the university: January 9, "Influenza and common colds," by Dr. A. W. Hewlett. January 23, "Migration as a factor in communicable diseases," by Dr. W. N. Dickie, secretary of the State Board of Health. February 6, "Parasitic infections," by Dr. N. E. Wayson, U. S. Public Health Service. February 20, "Constipation and auto-intoxication," by Dr. W. C. Alvarez. March 6, "Loss of life from preventable diseases," by Dr. W. C. Hassler, health officer of San Francisco. March 20, "Vaccines and serums," by Dr. E. W. Schultz.

THE means for future production of oil from government reserves of coal and oil shale is the subject of a conference recently held at the Interior Department by technologists of the Navy, the Bureau of Mines and the Geological Survey. A research program to aid the commercial development of processes by which oil may be obtained from oil shales, lignite and other coal is being planned by the Bureau of Mines. The Navy was represented in the conference by Rear Admiral H. H. Rousseau, Commander N. H. Wright and Lieutenant Commander W. H. Osgood. The Geological Survey was represented by Dr. David White, W. T. Thom, Jr., fuels geologist, and W. H. Bradley, oil geologist. O. P. Hood, chief mechanical engineer in charge of the Fuels Division of the Bureau of Mines presided. A report was made upon recent research in foreign countries by A. C. Fieldner, superintendent of the Pittsburgh experiment station of the Bureau of Mines, who has just returned from a trip of inspection through European laboratories and carbonization plants. Reports were also rendered upon recent research in the fuels and petroleum laboratories of the Bureau of Mines.

IT has been officially announced that the metric system will be used exclusively in the Dutch East Indies, by which Amsterdam pounds and piculs will be abolished. Heretofore the two systems have been functioning side by side, but it is now held that experience shows that the metric system is preferable.

To develop greater facilities for research and investigations, the Graham Brothers Truck Co., Evansville, Ind., manufacturer of motor trucks, has completed plans for a new metallurgical laboratory, to be two-story, brick and concrete, 50 x 60 feet, costing about $30,000, with equipment.

UNIVERSITY AND EDUCATIONAL NOTES

THE Rockefeller Foundation has given 10,000,000 dinars (about $200,000) to Jugo Slavia for the construction of a school of hygiene at Zagreb, the administrative capital of Croatia; $40,000 for the improvement of sanitary institutions in Belgrade, and $15,000 for the aid of needy students abroad who pledge their services after graduation to the public health service in Jugo Slavia.

UNDER the terms of the will of the late George St. John Sheffield, of Providence, son of the founder of the Sheffield Scientific School at Yale University, the university will receive the greater portion of the testator's estate after the death of his widow.

UNDER the terms of the will of the late R. J. Edwards, of Boston, a trust is established for the benefit of his two sisters, and on their deaths $100,000 will go to the Harvard Medical School to create the "Jacob Edwards Fund" in memory of the testator's father. The income of the fund will be used for research.

FIRE, believed to have been caused by an overheated furnace, completely destroyed the mines building at the University of Washington on December 17, with a loss of more than $125,000.

DR. JAMES C. FLIPPIN, professor of clinical medicine at the University of Virginia Medical School, has been appointed acting dean of the school, following the death of Dean Hough.

DR. A. C. BACHMEYER, superintendent of the Municipal Hospital, Cincinnati, has been appointed dean of the Medical College of the University of Cincinnati.

JOSHUA A. COPE, assistant state forester of Maryland, has been appointed assistant extension professor of forestry at Cornell University, and John N. Spaeth, formerly at the Harvard University Forest, was recently named assistant professor in the College of Agriculture.

CHARLES E. PACKARD has been appointed instructor in zoology at Allegheny College.

DR. RENÉ LERICHE, agrégé professor of surgery at the Lyons Faculty of Medicine, has been called to the chair of surgery at the University of Strasbourg, which has been vacant for some time.

DISCUSSION AND CORRESPONDENCE

SPECTROSCOPIC OBSERVATIONS OF THE ECLIPSE OF JANUARY, 1925

MAY I call the attention of physicists whose laboratories are situated outside of the track of totality of the eclipse of January 24, 1925, to the fact that for certain spectroscopic observations they are better placed than if they were situated within the track. For points where from 92 per cent. to 99 per cent. of the sun's diameter is covered by the moon, it has been shown that the spectrum of the lower chromosphere can be studied at length with the slit spectroscope and exposures may be made many times longer than in the two or three seconds that are possible at the beginning and the end of totality. By keeping the tip of a cusp on the slit interesting results may be expected. A large objective is not necessary for forming the solar image, but of course the low altitude of the sun will be unfavorable at this eclipse. Those interested should consult the articles by Professor H. F. Newall, of Cambridge, and Professor A. Fowler, of London, giving the results of their observations of the partial eclipse of April, 1912 (see the *Monthly Notices* of the Royal Astronomical Society, Vol. 72, pages 536–541). Those not having access to this volume will find a quotation from these articles in *Popular Astronomy*, vol. 26, no. 255, May, 1918. This will be the last total solar eclipse visible in the United States for twenty years.

EDWIN B. FROST

YERKES OBSERVATORY,
WILLIAMS BAY, WISCONSIN

HOW THE WORKS OF PROFESSOR WILLARD GIBBS WERE PUBLISHED

IN SCIENCE of September 26, 1924, Supplement, p. x, Professor F. G. Donnan, of London, is reported to have quoted Henry Adams as saying that after Benjamin Franklin, Gibbs was the greatest man of science that America has produced, and that "Gibbs ranks with men like Newton, Lagrange and Hamilton." Similar statements were made by speakers at the dedication of the new Chemical Laboratory of Yale University and elsewhere. It is not my purpose to oppose such opinions, nor to question his eminent ability.

Specialists in other very different sciences might, and probably do, have other estimates. Many would, perhaps, name Professor James D. Dana as the greatest scientist, for he was eminent in three very diverse sciences: Geology, mineralogy and zoology,

to all of which he contributed classical works, as well as widely known text-books.

It may be of some historical interest to recall the peculiar circumstances connected with the publication of the famous memoirs of Professor Gibbs on which his great reputation rests. They were published in the Transactions of the Connecticut Academy of Sciences, which at that time was not connected with Yale University and received no support from it.

Much later Yale decided to grant the Academy $1,500 annually towards its publications, which are now marked as Yale Publications. When Professor Gibbs presented his papers the academy had no regular publication funds, except the annual dues of the members—about 100 at that time.

I was on the publication committee in each case and was president of the academy during most of that period. As I am the only survivor of the committee I take the liberty to refer to the difficulties encountered in publishing those articles.

They were expensive to set up, owing to the complex mathematical formulae. Our funds were small. On nearly every occasion we had to go out and raise a subscription to pay the cost, partly among college men and partly among the business and professional men of New Haven. Long discussions took place as to our ability to print the articles. Two able mathematical professors were on the committee—Loomis and Newton. Both protested that they did not understand Gibbs's papers at all. One insisted that no man ever lived who could except Maxwell and he was dead. Yet we all believed that what Gibbs wrote must be of intrinsic value in his branch of science. Therefore we raised the money and printed each paper as it came in. I remember that on one of these occasions Professor Loomis, as chairman, appointed Professor Newton as one to raise funds. Professor Newton begged off because he had done that duty so many times, but Loomis would not excuse him because he was the most successful, and then in his usual sudden or abrupt way, he adjourned the meeting and seized his cane and tall silk hat to leave the room.

Professor Newton jumped up and said, "Hold on, Professor Loomis, I have something to show you." Then he took from his pocket a subscription blank already prepared and said, "I want you to head the list with $100.00." We all laughed, of course. Professor Loomis looked at us with a broad smile and without a word wrote his name down on the $100.00 page.

Not long after the publication of his papers, Professor Gibbs asked me to request a vote of the academy at a regular meeting as to giving permission to somebody in Germany to reprint his papers there. I told him that it was not necessary, for they were not copyrighted. He rather insisted on a vote. The vote was put and the vote was unanimous in favor of giving permission. Soon afterwards they were printed in several other European countries and finally became text-books in some of the universities.

Whether any other American society would have undertaken to publish those very advanced papers I do not pretend to know, but I think it very doubtful. We knew Gibbs and took his contributions "on faith." Yale University, as such, had no part in it. Most of the Yale scientific professors were members of the academy, but they acted individually for many years. Yale had not then, nor does it now, have any adequate means for publishing the results of the researches of its scientific men, so that their works are widely scattered.

A. E. Verrill

New Haven, Connecticut

AN EARTHQUAKE PREDICTION AT HAWAIIAN VOLCANO OBSERVATORY

A prediction of earthquakes was issued by the Hawaiian Volcano Observatory on April 8, 1924, and shocks that verified the prediction were felt over southeastern Hawaii on the 10th and 11th.

As was pointed out by Milne[1] earthquake predictions in a country where shocks are very frequent are almost certain of verification, especially if instrumental records are consulted. An average of seven or eight earthquakes are recorded weekly at Hawaiian Volcano Observatory. Of this number, however, only about five or six per cent. are perceptible. To forecast perceptible shocks and to give approximate time is not so easy as the total number of shocks might indicate.

In Hawaii, as elsewhere, there are a great many people who think that they can sense the coming of earthquakes. While the movement of barometric minima may have a slight effect on the occurrence of earthquakes it does not follow, even in regions of high seismicity, that sultry weather is followed by earthquakes. During the first part of 1924 in Hawaii, for instance, there was a long spell of "earthquake weather," with an unusually small number of earthquakes.

The small shocks that often precede a major one do, however, frequently enable one to make forecasts. Probably all the bona fide predictions mentioned by Milne[1] based on noises, uneasiness of animals or changes in underground water are due to fore shocks.

It has long been known that internal stresses of the earth are often shown at the surface by either

[1] Milne, "Earthquakes," pp. 301–310.

vertical or horizontal movements or by both. Lawson in his paper, "The prediction of earthquakes," draws his deductions mainly from measured horizontal movements in California. Over a large part of any region where there is a change in the vertical there usually is a deflection of the plumb line. Exceedingly small deflections can be measured from the tilting of sensitive pendulums. Jaggar[2] has shown the connection between tilt at Hawaiian Volcano Observatory and fluctuations in the lava column of Halemaumau. It is probably less reliable to make earthquake predictions from the tilt records of one station on the brink of an active volcano than from the records of a station more remote from a volcanic vent. So far at the Hawaiian Volcano Observatory there have been no measurements of horizontal movements. Steps were taken by Dr. Jaggar in cooperation with the U. S. Geological Survey to locate accurately several points near the volcano so that both horizontal and vertical movements might be detected. Tilt is also measured at Kealakakua, Kona, where a seismograph is maintained by the Hawaiian Volcano Research Association. It is a part of the program of this observatory to extend tilt measurements to other parts of the island. The amount of movement on the island of Hawaii is so great that it is possible to supplement the continuous records of a few stations by occasional measurements of accumulated tilts at other places with a precise level.

It is presumably not incorrect to say that if the movements, either vertical or horizontal, or both, that are occurring in probably all seismic regions of the world could be measured continuously few serious earthquakes would be likely to occur unheralded.

At the Hawaiian Volcano Observatory, on the north brink of Kilauea crater, there was a southerly tilt during most of March. On March 29 a northerly tilt set in that continued until the evening of April 2. From April 3 to April 8 there was a southerly tilt amounting to about six seconds of arc. The tilt accumulation of six seconds in such a period of time is by no means uncommon, especially during times of rapid changes in the lava level in the fire pit, half of the above amount sometimes occurring in one day. With these rapid fluctuations of the molten lava and large tilts there are, as a rule, but few perceptible earthquakes. During the period in question, however, there was no molten lava in the fire pit. At times of little or no tilt whether there be lava in the pit or not there are but very few local shocks. The connection between tilt and earthquakes at such times has long been noticed here.

[2] Jaggar, T. A., *Bull. Seis. Soc. Amer.*, Vol. 10, No. 4, Dec., 1920.

Accordingly, on April 8 the following statement was sent to Hawaiian newspapers: "There is strong likelihood of one or more perceptible earthquakes within a few days." At 10:46 P. M. April 10 an earthquake occurred that was felt all over southeastern Hawaii, and the following day at 11:24 A. M. another shock of a little less intensity occurred.

R. H. Finch

Volcano House, Hawaii,
May 1, 1924

A NEW FORMATIONAL NAME

In 1912 I described in the Journal of the Academy of Natural Science of Philadelphia (pp. 23–112, pls. 5–13), the occurrence of true basal Eocene beds on the Island of Soldado, off the southwestern coast of Trinidad, in the Boca de Serpiente, and I described and figured the fossils.

This fauna, which is that of bed No. 2 of the Soldado section, showed extremely interesting analogies on the one hand with the northern fauna of the Midway, basal Eocene of Alabama, and on the other hand with the southern basal Eocene of Pernambuco, Brazil.

The subsequent work of various geologists in the Antillean and northern South American field has strengthened and corroborated the age of this Soldado horizon, which has been traced upon the mainland of Trinidad. Beds of similar age are also on the Island of Margarita.[1]

But the Soldado horizon has become historic as the first discovery of the true basal Eocene in the entire Antillean and northern South American region. It is fitting that it should receive a distinctive name, and I propose that it should be known as The Soldado Formation and stand as the type of northern South American and of Antillean basal Eocene deposits.

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[1] Maury, *American Journal of Science*, in press.

QUOTATIONS

THE ENCOURAGEMENT OF BASIC RESEARCH

The National Union of Scientific Workers has issued a report on the encouragement of basic research, in which it discusses the value of research to the community, the motives of research workers, the financial encouragement they should receive, and the obligations of their work. The views expressed in this report are of peculiar interest because they represent the opinions of people actually engaged in scientific investigations, who are themselves familiar, therefore,

with the difficulties which attend this mode of life, with the misconceptions entertained about it and with the defects that follow from lack of organization. The National Union of Scientific Workers is not a trade union designed to protect a particular section of the community. It exists to further a cause which all scientists have at heart, and to voice the opinions of a valuable band of citizens who have been too long inarticulate.

The motives of research workers are, speaking generally, as mixed and as commonplace as those of their neighbors. It is well to recognize this fact, and to discard the illusion that the research worker necessarily pursues a lofty course inspired by an ideal superior to that which moves the remainder of mankind. One of the most powerful motives of the research worker is undoubtedly a desire for knowledge for its own sake; but mere love of knowledge, unaccompanied by any other motive, is seldom sufficient to lead to the laborious investigation imposed by research. The desire for reputation, not to be confused with base ambitions towards notoriety, is a worthy motive in research workers; many of them have enjoyed the companionship of older scientists, whose approval they look for as a gratifying reward. The expectation of being able to publish an important piece of research, and thereby earning a position in the ranks of some learned society, determines the choice of a way of life for many younger scientists. In medical science the pecuniary rewards of research work are not, and are never likely to be, as substantial as those of the practicing physician or surgeon, but the atmosphere of the laboratory offers attractions unknown in the busy consulting room or operating theater; such attractions are leisure to think, freedom from interruption and free play for the imagination. Among motives we have to reckon also with a desire for some more responsible post, such as a professorship, with its attendant intellectual status and greater security.

It is interesting to notice that when discussing the financial encouragement which should be given to research the National Union of Scientific Workers unsparingly condemns the system of patents, prizes and special grants for successful work. Payment by results is an impossible method for research work, because, as experience has shown, the most fruitful work has often been some fundamental inquiry into a scientific problem which seemed to offer very little prospect of practical gain. To dictate a practical objective would hamper much useful investigation. Moreover, it is extremely difficult justly to apportion credit for a discovery. The individual to whom the coveted distinction is ascribed has sometimes done little more than add the final stone to a building whose foundations have been laid and whose walls have been built by a host of workers of whom the world never hears. On the other hand, indirect encouragement by means of special grants for apparatus and assistance in publication of results is approved as a satisfactory method of financial encouragement.

It is recognized that some scientists can only do the best kind of research work when completely free from all other duties, such as teaching or routine work. Provision must be made for workers of this temperament, and they must be guaranteed a salary sufficient to enable them to be secure from financial anxieties. Other research workers prefer to combine some routine work with their experimental studies, and these are most happily employed in some university or hospital appointment, which enables them to spend part of their day in teaching and the other part in research.

The National Union of Scientific Workers is wise in insisting on the value of research to the community, for this is an aspect of the research question often unnoticed. Apart from the store which research workers add to the knowledge of the country, the inclusion of men and women with the research type of mind should be sought after in every community. Open-mindedness and breadth of view are developed by the search for truth, and the whole community benefits directly by the presence within it of such intellectually active citizens, who contribute qualities that can not be conferred in the same measure by any other intellectual occupation.—*The British Medical Journal*.

SCIENTIFIC BOOKS

Food Products. By HENRY C. SHERMAN. 2nd Edition, Revised and Enlarged. The Macmillan Company, New York, 1924, VII plus 687.

THE years immediately preceding the first edition of H. C. Sherman's "Food Products" had witnessed a great increase of interest in food problems and a corresponding increase in knowledge of food composition and likewise a rapid development of the important subjects of food sanitation and legislation. Out of the greatly augmented subject-matter then available a clearly written and very inclusive book was produced which has proved of great value in every way to teachers and students as well as a handy and convenient reference book for the general public. A feature of this book and of the new edition is the lists of references following each of the chapters, which makes it possible for the user to locate readily material which supplements and extends the chapter content.

The new volume is a logical development of its predecessor. The experience of the last ten years and

the important developments in study and research have been drawn upon and used with the older material to make a consistent whole. Several chapters have been completely rewritten and two new chapters have been added. Certain rearrangements have been made in the interests of teaching, which like other changes reflect the experience of the years of classroom use by the author and others, but the general sequence of topics followed in the first edition, which means a chapter devoted to each important type of food, is unchanged. In both editions the following subjects are treated: production and preparation for market with statistical and economic data; proximate composition and general food value, sanitation, methods of inspection and standards of purity; and composition, digestibility, nutritive value and place in the diet.

The last decade has witnessed a very great interest in vitamins and a large addition to the knowledge of them. This newer work is particularly well treated in the book and in such a way that it falls into line with other factors which make up food value.

A new chapter deals with food adjuncts, unclassified food materials and extra foods eaten between meals, as well as salt, spices, flavoring extracts, vinegar and household and commercial beverages, substances about which information is not readily available. There is also a new chapter on food budgets and food economics.

The appendices are an important feature of this volume, as of the earlier one, and have been increased by a table on food products as sources of vitamins A, B and C, and another dealing with food legislation.

The subject index which concludes the volume is full and well arranged.

It is evident that the author has taken unusual pains in the selection of his material and in its arrangement and presentation and it is a readable book as well as a text-book and work of reference for general use.

As should be the case the author in making this book has drawn largely on his own extensive and important research work and study of food and nutrition problems. This adds not only to the interest of the book but greatly to its value.

C. F. LANGWORTHY

WASHINGTON, D. C.

Evolution or Christianity. By WILLIAM M. GOLDSMITH, Ph.D. The Anderson Press, Winfield, Kansas. 50 cents.

UNDER the title of "Evolution or Christianity," Professor William M. Goldsmith undertakes to meet the various anti-evolutionists on their own ground. He considers patiently all those whose ideas are in print, showing in what degrees each can be convicted of ignorance or dishonesty. Meanwhile he upholds the belief that there is no necessary conflict between Christianity and evolution, except when one or both is grossly misunderstood. There is no conflict between verified knowledge, on the one hand, and the sense of awe, reverence, duty and love on the other. The warfare of science rages around non-essentials.

Dr. Goldsmith is a young teacher of science, well trained and well informed. His work is issued in cheap form for wide distribution. It is a response to a real need in these days, and it is a pity and a shame that such necessity exists.

DAVID STARR JORDAN

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SPECIAL ARTICLES

ULTRAVIOLET LIGHT AND SCURVY

IN his most interesting "Treatise on Scurvy," written in 1757, Lind repeatedly emphasizes the fact that scurvy is more prevalent in northern latitudes and that it usually occurs in southern latitudes during the rainy season and is improved by change of weather. He speaks of the fact that in several channel cruises when the weather was fine there was no scurvy aftr 12 weeks, but that on two cruises during cold rainy weather scurvy broke out in a month. In view of the fact that ultraviolet light can prevent the occurrence of rickets, Lind's book at once suggests that it may have been the lack of sunlight rather than the presence of moisture which led to outbreaks of scurvy during the rainy season.

This possibility is strengthened by a review in the *Lancet* (Vol. 1, 1917, p. 462) which states that in the winter of 1915 the Turkish wounded, who were suffering with scurvy, were greatly improved by exposure to sunlight. These results naturally suggest that ultraviolet light might have a beneficial effect both in the healing and in the prevention of scurvy. However, three series of experiments on guinea pig scurvy have shown entirely negative results.

Experiment I: Twelve guinea pigs, weighing about 290 gms each, were divided into two lots, with some light and some dark animals in each group. Six were depilated once a week on one side over an area of approximately 15 sq cm and radiated daily for 10 minutes at a distance of 12 inches from a Hanovia Alpine Sun quartz mercury arc, running on 110 D.C. at 58 volts and 3 amperes (11 lithopone units of ultra-violet light). The guinea pigs showed a very marked erythema followed by desquamation. A control experiment showed that the depilation in itself did not affect the health or rate of growth of the animals.

The other six animals were used as controls and all twelve were given oats, hay and water ad libitum. Both sets showed loss in weight after the twelfth day, especially the radiated group. On the twenty-third day, two animals being dead in the non-radiated group, and three in the radiated group, radiation was stopped and orange and cabbage were added to the diet.

Autopsies showed approximately the same picture in both radiated and non-radiated animals. The molars were loose and there was marked hemorrhage of the shoulder joints. There was some beading of the ribs and a very marked white line at the epiphyseal junction. The intestines were practically empty, but there was no subcutaneous edema, such as is said to be present in death by starvation. There seemed no doubt that the animals were suffering from scurvy, in both the radiated and non-radiated group, although death may have been hastened by starvation.

The weight curves of two surviving animals in each group are plotted in Fig. 1. No radiation was given for a week, but then, all the animals being apparently well on the way to recovery, the radiated set were radiated again and given the same dose every other day. They immediately stopped gaining weight, developed severe diarrhea and eventually died. The first one to die still showed signs of scurvy on autopsy, but the other showed no scorbutic lesions at the time of death.

Experiment II: In the second experiment six guinea pigs were placed on a diet of oats and bran (two thirds oats and one third bran) to which 3 per cent. of butter fat was added to give an adequate supply of vitamin A. Three animals were kept as controls and the other three were depilated and radiated for 10 minutes at 12 inches from the quartz mercury arc (11 lithopone units) every other day.

There was a rapid fall in weight after the eighteenth day and all animals in both groups showed a severe diarrhea, which may have been due to too large a percentage of butter fat in the diet. On the twenty-fourth day one animal died in each group, so the butter was discontinued and orange and cabbage added to the diet. The picture on autopsy was only slightly different from that in Experiment I.

The non-radiated group began to improve as soon as the diet was changed. The two radiated animals, on the other hand, though not radiated any more continued to lose weight and suffer from diarrhea, and both died at the end of another week.

The results of this experiment indicate that a plentiful supply of vitamin A keeps up the weight of the animals for two weeks or more, but on this diet, as on the preceding one, radiation with ultraviolet light proved ineffectual in preventing or postponing scurvy and seemed to prevent a cure when the diet was changed.

Experiment III: In this experiment an attempt was made to supply a diet which had an adequate supply of vitamins A and B and also a proper salt ration. Insufficiency of the antirachitic vitamin should have been compensated for by the ultraviolet light. The diet consisted of 91 per cent. oats, 2 per cent. butter fat, 2 per cent. calcium lactate, 2 per cent. sodium chloride and 3 per cent. dried yeast (Fleischmann's).

There were four groups, with six animals in group II and five in each of the other groups. They were given the following treatment.

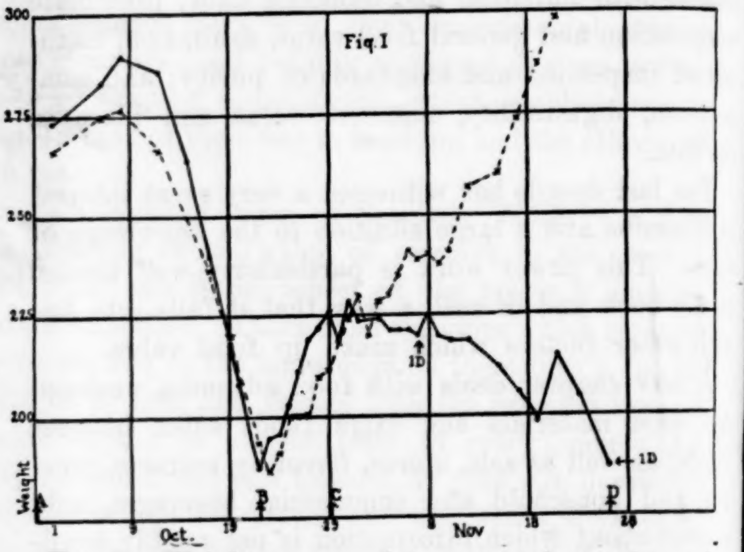

FIG. 1. Weight curves of two surviving guinea pigs in each group in Experiment 1. x - - - - - - x not radiated ————. Radiated (A-B) and (C-D). Diet started at (A) and cabbage and orange added at (B).

Group I: Controls, scorbutic diet, no radiation.

Group II: Scorbutic diet, exposed to sunlight one half hour every clear day, area depilated on back.

Group III: Scorbutic diet, side depilated and radiated every other day with 5.5 lithopone units if white, and 11 lithopone units if dark.

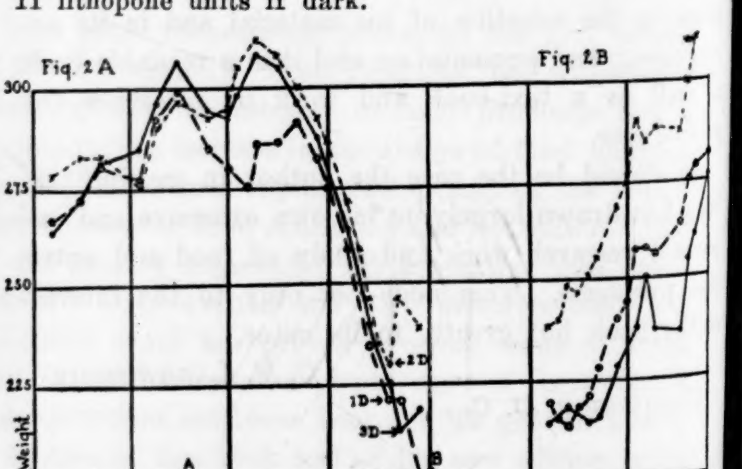

FIG. 2 (A) Weight curves of three groups in Experiment III. x - - - - - x not radiated, o ——— o radiated with sunlight .————. radiated with quartz mercury arc. Diet started at (A) and cabbage and orange added at (B). 2 (B) Recovery curves of surviving animals in groups I, II and III. (Experiment III.)

Group IV: Given same mixture as other groups with addition of greens, two animals depilated and given 5.5 lithopone units every other day, other three not radiated. This group showed very clearly that, on a normal diet, ultraviolet light did not hinder growth.

Groups I, II and III gave almost identical results. After the eleventh day there was a rapid loss of weight at exactly the same rate in all three groups. Only one or two animals, however, showed any sign of diarrhea. The results plotted in Fig. 2 (A) show conclusively that on this diet, as on the two preceding ones, ultraviolet light had no effect in preventing or postponing scurvy and sunlight seemed equally ineffectual.

The autopsies showed the same lesions as in the previous experiments. The recovery curves of the three animals left in group I and the two left in each of groups II and III, after the addition of orange and cabbage to the diet, are given in Fig. 2 (B), groups II and III being radiated as before. All three groups recovered at approximately the same rate so that after the production of scurvy on this diet subsequent radiation with ultraviolet light did not prevent recovery. This may have been due to the better diet but may also have been due to the fact that less radiation was given than before.

CONCLUSIONS

Three experiments with different scorbutic diets showed that ultraviolet radiation is entirely ineffectual in preventing or postponing scurvy. With diets in which other factors, besides the scorbutic vitamin, were lacking, ultraviolet light hastened loss of weight and death from scurvy somewhat and prevented recovery after orange and cabbage were added to the diet. This, however, was not true when a diet lacking only in the antiscorbutic vitamin was used.

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EFFECTIVE DUST TREATMENTS FOR THE CONTROL OF SMUT OF OATS

THE use of copper dusts for the control of certain smuts of cereals has received considerable atttention by investigators in America during the past four or five years. The report of Darnell-Smith, of Australia, in 1919 provided the stimulus for a change of the trend of research in this connection, by diverting attention from the sprinkling and soaking methods previously employed, to the use of dusts. This form of treatment presents a new idea in seed disinfection. By the use of a weak, slowly available fungicide, infection is prevented coincident with the germination of the grain in the soil, yet by reason of the low solubility of the chemicals used, the seed is not likely to be injured.

Most effective and consistent results have been obtained in the control of covered smut of wheat with copper carbonate. In the case of covered and loose smuts of oats, results have been variable. While copper and nickel compounds used as dusts have greatly reduced the amount of smut in nearly all instances, their fungicidal efficiency has not been sufficient to provide commercial control and to merit general recommendations.

After three years of trial in Ohio, no copper or nickel compound used alone as a dust has been found adequate for the control of oats smut. On the other hand, when combined with mercuric chloride the mixture proved to possess a fungicidal value which compared very favorably with formaldehyde.

In treating grain it is not only desirable that the fungicide used should be effective for the control of smut, but also that the germination of the seed should be stimulated or, at least, not impaired. The data presented in the table indicate that with the copper and nickel compounds combined with mercuric chloride there was marked stimulation in the germination of the grain. This is not apparent in the plots treated with formaldehyde.

In the preliminary tests one part of the copper or nickel salt and two parts by weight of mercuric chloride were thoroughly mixed and ground together. This mixture was used at the rate of three ounces per bushel for treating grain. The mercuric chloride, when used alone, was found to have very poor adhesive properties; also, because of its high comparative cost and extreme degree of toxicity, it would be less desirable than when used with some other compound which would serve as a carrier. The basic idea involved is to add just enough of the mercuric chloride to the copper or nickel salt that the fungicidal value of the mixture may be raised to the required efficiency for oats smut control. Further trials will be necessary to more accurately determine the minimum amount of the salts that may be effectively

RESULTS OF SEED TREATMENTS

The table gives in the first column the per cent. of smut; in the second the per cent. stand on basis of check, and in the third the per cent. of gain or loss due to treatment

Check	32.	100.	—32.
Formaldehyde sprinkling method	.00.	87.5	—12.5
Formaldehyde diluted 1-1 with water	.01	97,2	— 2.7
Formaldehyde dry diluted 1-10 with water.	.007	94.2	— 5.7
Copper carbonate	4.6	105.3	+ .7
Copper carbonate plus mercuric chloride.	.05	101.5	+1.45
Copper sulphate (not anhydrous)	11.4	102.0	— 9.4
Copper sulphate plus mercuric chloride...	.7	112.7	+12.0
Nickel carbonate	3.6	100.7	— 2.9
Nickel carbonate plus mercuric chloride..	.5	111.1	+10.6
Copper acetate	8.0	107.0	— 1.0
Copper acetate plus mercuric chloride...	.5	116.0	+15.5

employed, also with the end in view of reducing the cost of the mixture.

Roy C. Thomas

Ohio Agricultural Experiment Station

THE GEORGIA ACADEMY OF SCIENCE

The Georgia Academy of Science held its third annual meeting on November 21 and 22 at Emory University. Officers for the ensuing year were elected as follows: L. L. Hendren, University of Georgia, *president;* G. H. Boggs, Georgia School of Technology, *vice-president;* Henry Fox, *secretary-treasurer.* The following persons were elected members of the executive council: C. R. Fountain, Mercer University; N. P. Pratt, Citizens and Southern Bank, Atlanta, and R. P. Stephens, University of Georgia.

The following minute was adopted and ordered to be entered on the records of the academy:

Dr. William Henry Emerson, dean and professor of chemistry in the Georgia School of Technology, and charter-member of the Georgia Academy of Science, died on Thursday, November 13, 1924, in the sixty-fifth year of his age.

Dr. Emerson was a distinguished chemist, an energetic and laborious investigator and an inspiring and successful teacher. A modest, gentle and lovable personality he won and held the respect and affection of all with whom he was associated.

In his death science has lost a brilliant votary, the state a most valuable citizen, the School of Technology a loyal and devoted officer and administrator, and the Academy of Science an honored and beloved member.

This minute is inscribed in token of the admiration and esteem entertained by the members of the academy for Dr. Emerson and of the great sorrow occasioned them by his death.

The following persons were unanimously elected members of the academy: Dr. George Bachmann, professor of physiology, Emory University; Dr. E. R. Clark, professor of anatomy, University of Georgia Medical School; Dr. M. P. Jarnagin, professor of animal husbandry, State College of Agriculture; Mr. R. D. Kneale, chief engineer, S. E. Findley Co.; Dr. Edwin Linton, professor of parasitology, University of Georgia Medical School; Dr. Mary S. MacDougall, professor of biology, Agnes Scott College; Dr. J. L. McGhee, professor of chemistry, Emory University, and Dr. J. F. Messick, professor of mathematics, Emory University.

The following papers were presented at the meetings:

Some additional evidence of the interference principle in osmosis: J. L. McGhee.

Selection in castor beans: T. H. McHatton.

Some new organic fluorides: O. R. Quayle. (Introduced by J. S. Guy).

Two troublesome fungi: E. S. Heath.

Stone Mountain flora: E. S. Heath.

Determinism, mechanism and freedom of the will: A. S. Edwards.

Recent discoveries in archeology: W. A. Shelton. (Read by title.)

Porocephalus cordeli. A new species of Lingualid from Georgia: Joseph Krafka, Jr. (Read by title.)

Illustrated talk on Stone Mountain: S. W. McCallie.

Tetraploidy: Mary S. MacDougall.

The relation of the vagus nerves to the atrio-ventricular nodes: George Bachmann.

History of science in Georgia: R. P. Stephens.

Absorption spectra of solutions: J. S. Guy.

Types of mathematical relations as they occur in general physics: L. L. Hendren.

The Lewis-Langmuir structure of the atom applied to complex compounds: C. J. Brockman. (Introduced by R. P. Stephens.)

A study of certain factors involved in the course of laboratory infections with Plasmodium praecox: G. H. Boyd. (Introduced by R. C. Rhodes.)

Treatment of malaria in birds: G. H. Boyd.

Henry Fox,
Secretary

BIOLOGICAL MEETING AT RIVERSIDE, CALIFORNIA

A joint meeting of the San Jacinto Section of the Western Society of Naturalists and the Synapsis Club of the Citrus Experiment Station of Riverside was held on October 31 and November 1. On the first day of the meeting President H. S. Foster presided at the reading of the following papers:

Afferent and efferent pathways in the nervous system: Dr. W. A. Hilton, Pomona College.

Remarks concerning Pacific plankton diatoms of tropical and temperate waters: W. E. Allen, Scripps Institute for Biological Research, La Jolla, Calif.

Chromosomes of Citrus: Illustrated with lantern. Dr. H. B. Frost, Citrus Experiment Station, Riverside, Calif.

A recent collecting trip in Florida and Alabama: Illustrated with lantern. Dr. F. B. Sumner, Scripps Institute for Biological Research, La Jolla, Calif.

A sphinx among fishes: O. D. Howard, University of Southern California.

The first day's meeting was held in the science lecture room of the University of California, Southern Branch.

On November 1, the societies met at 10 A. M. for a field trip to Del Rey in charge of Dr. Loye Miller, of the University of California, Southern Branch, to study marsh, sand dune and beach life.

The officers elected for the following year were: *President,* Dr. O. L. Sponsler, University of California, Southern Branch; *Secretary-treasurer,* Dr. W. A. Hilton, Pomona College.